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# SUPERIOR PULMONARY SULCUS TUMOR*

## A CASE EXHIBITING A MALIGNANT EPITHELIAL NEOPLASM OF UNKNOWN ORIGIN WITH PANCOAST'S SYNDROME

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UNDER the descriptive phrase, "superior pulmonary sulcus tumor," Pancoast[11] in 1932 drew attention to a group of cases exhibiting, in common, a neoplasm at the apex of the lung extending into the supraclavicular fossa, pain referable to involvement of the brachial plexus, atrophy of the soft tissues and muscles of the affected area, the early development of Horner's syndrome, and evidence of destruction of bone in the neighborhood of the neoplasm. He has reported 8 such cases, 2 of which exhibited carcinoma in biopsy material. No tissue was examined in the other cases. In an earlier report, Pancoast[10] had expressed the opinion that the tumor in some of his cases was either of pleural origin or a sarcoma of bony origin. He pointed out then that many conditions will produce the symptom-complex of pain and cervical sympathetic paralysis. He mentioned among them spinal cord or meningeal tumors, neoplasms of the vertebrae, some tumors of the neck, cervical rib and trauma. He also stated that cervical sympathetic paralysis alone may be caused by many lesions, e.g., neck tumors, enlarged lymph nodes, trauma, aneurysm, mediastinal tumors and pulmonary tuberculosis.

Since these reports by Pancoast several writers have opposed his idea that apparently primary tumors in this region arise from remnants of branchial clefts. Fried[4] described a case of *intra*pulmonary carcinoma occupying the left upper lobe associated with cough, expectoration, thoracic pain, clubbing of the fingers and the late development of Horner's syndrome. Necropsy revealed, in addition to the neoplasm of the left upper lobe, metastases to the cervical and dorsal spine and ribs, and transverse myelopathy. In view of this and other similar cases, Fried felt that Pancoast had not ruled out the lungs as the source of the tumor in his patients. However, Pancoast[11] emphasized the *early* development of Horner's syndrome, the localization at the apex with growth into the surrounding nerves, bones, and muscle rather than into the lung, as points against a pulmonary origin. In a subsequent report, Fried[5] repeats his contention but mentions his own observation of a case exhibiting Pancoast's syndrome, which, at necropsy, showed *no* intrapulmonary neoplasm and he asserts that it arose from a branchial rest. He therefore seems to have changed his views to include the possibility of origin from a branchial rest in some cases exhibiting Pancoast's syndrome.†

Jacox[7] reported the necropsy findings in

† Since this paper was submitted for publication, a further report by Fried has appeared now substantiating the view that the superior cervical sulcus tumors may be of branchial origin (Fried, B. M. Sternoclavicular branchioma. *Am. J. Cancer*, 1935, *25*, 738–745).

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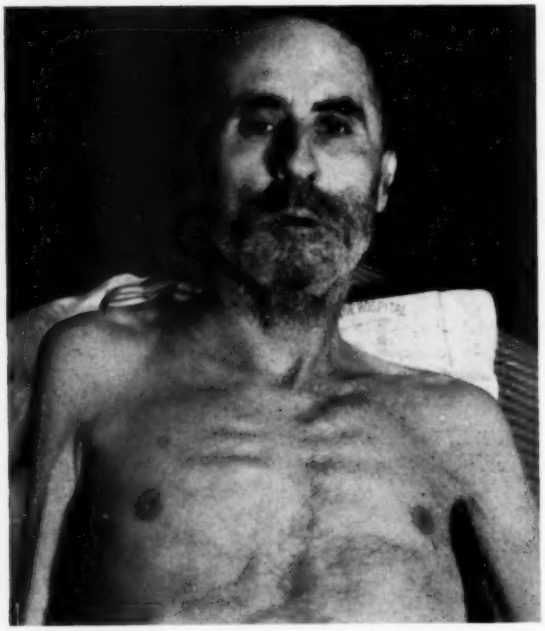


FIG. 1. A photograph of the patient taken two months before exitus. Note ptosis of the right upper eyelid (there was also slight enophthalmos) and the tumor swelling in the right supraclavicular fossa.

a case exhibiting the same syndrome with an apical pulmonary carcinoma and noted the histologic structure of the tumor to be adenocarcinoma capable of forming mucin. Weller, who reported the histologic findings in this case, commented that "since this carcinoma is an adenocarcinoma, it could not have arisen, so far as we know, in branchial cleft remains. Since it is mucin-forming the primary cannot be referred to the suprarenals. Both by direct evidence and by exclusion, one is forced to the conclusion that this is of bronchiogenic origin."

Steiner and Francis[13] under the term "primary apical lung carcinoma" have recorded the clinical and post-mortem findings in a case similar to Fried's. They also oppose Pancoast's ideas concerning the source of the tumor—without acknowledging the possibility of branchial vestigial origin in cases exhibiting *no* intrapulmonary tumor although at the apex.

Clarke[2] has recorded the clinical and post-mortem findings in a case exhibiting an epidermoid carcinoma at the apex of the left lung with pleural adhesions to the tumor but no pulmonary involvement. He felt unable to arrive at a definite decision as to its origin and believed that the different histological types found in neoplasms in this location may produce the same clinical and roentgenological findings.

Because we have had the opportunity of studying during life and at necropsy a classical case exhibiting the syndrome described by Pancoast and showing *no* pulmonary involvement or connection except by pleural contact, it seems worth while to record in detail the following case:

### CASE REPORT

F. L. male, aged forty-seven, married, salesman, was admitted to the Third (New York University) Medical Division of Bellevue Hospital on January 31, 1934, complaining of pain in the right arm of six months' duration and of a lump in the right supraclavicular fossa of one month's duration.

His illness began in July, 1933, about six months prior to admission, with pain and aches in the volar aspect of the right arm from the axilla to the wrist. This subsided after ten days and the patient was fairly well for the next three months, when the pain recurred. It now also involved an area about the size of a silver dollar over the dorsal aspect of the right shoulder.

Pain, at first intermittent, became constant and began to radiate down the arm from shoulder to fingers. It was burning, gnawing, and at times knife-like, making sleep impossible and necessitating large potions of sedatives.

Two months prior to entry the patient was advised to have his teeth extracted after a diagnosis of rheumatism. This procedure failed to relieve the pain.

A month prior to entry he noted a lump about the "size of a walnut" in the right supraclavicular area. It was painless to touch and gradually increased in size.

Latterly relief from pain could be obtained only by the hypodermic administration of morphine.

On admission he localized the pain to the entire right upper extremity from the posterior aspect of the shoulder to the finger tip associated with stiffness of fingers. He also described a band-like area of numbness 3–4 inches wide from the clavicle to an inch above the nipple on the right anterior chest wall.

Weakness had been progressive and there

was a loss of 10 lb. in weight. The only respiratory symptom was a slight infrequent non-productive cough. There was no hemoptysis or dyspnea. There were no other related symptoms.

Physical examination revealed an adult white male who appeared chronically ill. He was well developed but poorly nourished.

There was unilateral sweating on the left side of his head. The pupils were equal and reacted to light and accommodation, the right sluggishly. There was slight ptosis of the right upper eyelid with narrowing of the palpebral fissure; some enophthalmos was present on the right side (Fig. 1). The teeth were all missing, the tongue in the midline was coated. The pharynx and tonsils were negative.

In the right supraclavicular fossa there was a visible mass which was stony hard and attached to the underlying tissues. It measured 4 cm. in diameter.

There was dullness posteriorly over the apex of the lung from the level of the fourth dorsal vertebra to the second rib anteriorly. Over this area breath sounds were somewhat diminished. There were no other abnormal pulmonary findings. Examination of the heart revealed no abnormalities. Abdominal examination showed nothing abnormal.

There was general atrophy of the right upper extremity with marked atrophy of the intrinsic hand muscle and marked loss of power. Sensory examination of this limb showed no change to light touch, slight diminution of vibratory sense, increased sensibility to pain on deep pressure and percussion of bones. The deep reflexes were diminished. The remainder of the neurological examination was normal.

*Laboratory Data.* Wassermann reaction was negative. Blood pressure 130/90. Red blood count 5.7 million; hemoglobin 95 per cent (Dare); white blood count 10,800 with normal differential except for a shift to the left. Urine: specific gravity 1.015, acid reaction, no albumin or reducing bodies, no formed elements found on microscopic study. Blood non-protein nitrogen 32 mg. per 100 c.c.; sugar 125 mg. per 100 c.c.

*Roentgen Examination.* Gastrointestinal series, including roentgenoscopy, showed no abnormal findings. Examination of the colon after barium enema yielded no abnormalities. Roentgenograms of the chest and upper cervical regions disclosed the shadow of a mass at the cupola of the right lung adjacent to the vertebral column. There was evidence of destruction of the first and second ribs near the transverse processes of the spine. The mass appeared to extend downward to the level of the first interspace (Fig. 2). There was also a circumscribed area of increased density 2.0 cm. across in the posterior aspect of the sixth right interspace, corresponding to the upper portion of the right lower lobe.

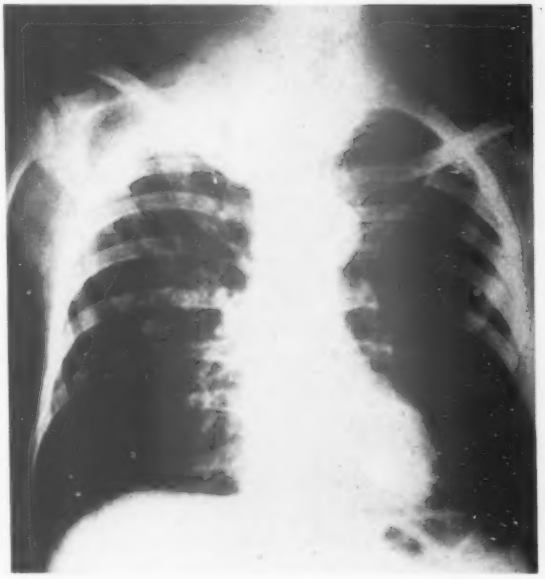


Fig. 2. A roentgenogram of the thorax and neck showing the area of increased density in the right supraclavicular and cervical areas. The circumscribed shadow in the middle of the right lung field was thought to be a metastasis, but was subsequently shown to be a quiescent tuberculous focus.

*Progress.* The patient's course was progressively downhill. The persisting pain required the administration of opiates. Rhino-laryngological studies revealed no tumor foci.

The neurologists concurred in the diagnosis of right-sided Horner's syndrome secondary to a neoplasm exerting pressure on the brachial plexus and inferior cervical sympathetic ganglia. A biopsy revealed an epithelial neoplasm showing malignant features and the diagnosis of a superior pulmonary sulcus tumor (Pancoast) was considered.

Radiation therapy was given during a period of eighteen days over the area of the tumor mass, anteriorly and posteriorly.

All the soft muscular tissue of the right upper extremity continued to atrophy. The wasting was particularly marked in the deltoid, triceps, and interosseous muscles of the hand with the resulting picture of main en griffe (ulnar distribution).

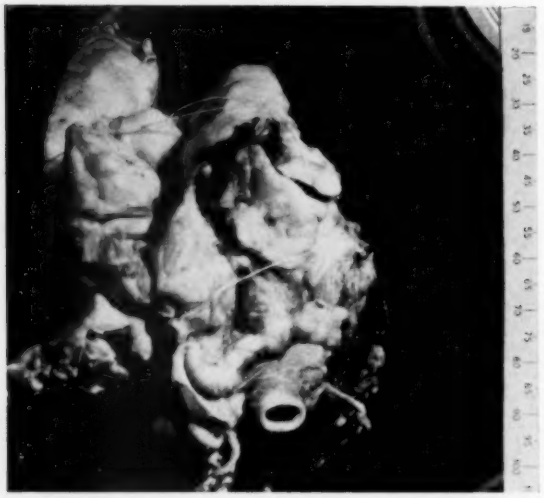


FIG. 3. A view of two large pieces of tumor tied together showing the common carotid artery entering the tumor.

Eleven weeks after admission the patient developed a series of clonic and tonic convulsions lasting about ten minutes. This was followed by a short period of unconsciousness and succeeded by a psychotic period of about ten minutes. Following this episode the patient behaved normally and exhibited no new neurological signs. Horner's syndrome persisted. Cerebral metastasis was considered but with no localizing signs, no definite diagnosis could be made.

New roentgenograms of the chest and neck revealed expansion of the tumor, with extension and destruction of the right lateral aspects of the sixth and seventh cervical vertebrae and the posterior halves of the first and second ribs, as well as the lateral processes of the first and second thoracic vertebrae.

A week before exitus the patient became comatose, incontinent of urine and had to be catheterized frequently. Vibratory pain and positional senses of both legs were lost. Fever rose and basal râles became audible at the bases of the lungs. The patient died on June 2, 1934.

*Pathologic Findings.* Necropsy was performed twelve hours post mortem and the incision was limited to the abdomen. There was marked evidence of loss of subcutaneous fat. The skin was inelastic. No abnormal findings were noted in the eyes, ears, nose or mouth, the latter being edentulous. In the right supraclavicular fossa there was seen and felt a firm globular tumor mass extending upward and posterior to the sternomastoid muscle. The overlying skin showed a short, well healed scar parallel to the clavicle. The skin otherwise was not attached to the tumor mass and showed no other changes. The tumor was extremely firm, but not stony hard. The chest and abdomen showed no external abnormalities. The right upper extremity was the seat of marked atrophy and had distinctly less subcutaneous fat than the left. There was also apparent wasting of the muscle on this side. The other extremities revealed no changes. The external genitalia appeared normal.

On section, subcutaneous fat was scanty; the peritoneal sac was free of fluid or adhesions. Upon opening the pleural sacs via the diaphragm no free fluid escaped but the lungs were felt to be voluminous. At the region of the right apex, the lung was felt to be adherent to the tumor mass palpable in the superior pulmonary sulcus; it was easily separated from the tumor without loss of parenchyma. Following removal of the lungs, the tumor mass was removed piece-meal. It was found to incorporate within it the head and neck of the first two ribs. It extended to and involved also the transverse processes of the seventh cervical, the first and second thoracic vertebrae. Palpation of the vertebral bodies revealed them to be roughened and involved the tumor processes. Pieces of these bones were removed for examination (Fig. 3). The substance of the tumor mass was extremely firm, slightly rubbery, generally yellowish or yellowish-white and cut with considerable resistance. One large piece (see Fig. 1) incorporated the carotid artery and part of the nerves of the brachial plexus. The total mass, when assembled, was estimated to measure $8 \times 6 \times 5$ cm.

Lungs: Were fairly voluminous, pale gray-red, and showed anthracotic subpleural deposits. At the apex of the right lung there was a flattened, smooth, yellowish plaque similar in appearance to the tumor tissue, but on section it was found to be confined to the pleura and did not extend into the parenchyma. In the region of the apex of the right lower lobe there was found a spherical, caseous lesion, 2.5 cm. in diameter, well encapsulated. Several small caseous nodules (daughter tubercles) were seen in the immediate vicinity of this lesion. Multiple sections of the lungs revealed no other focal lesions, and both lungs were moderately congested and edematous, and in both lower lobes there were several irregular patchy areas of lobular consolidation, slightly firmer and deeper red than the surrounding parenchyma. Tracheobronchial and bronchopulmonary lymph nodes were small and anthracotic.

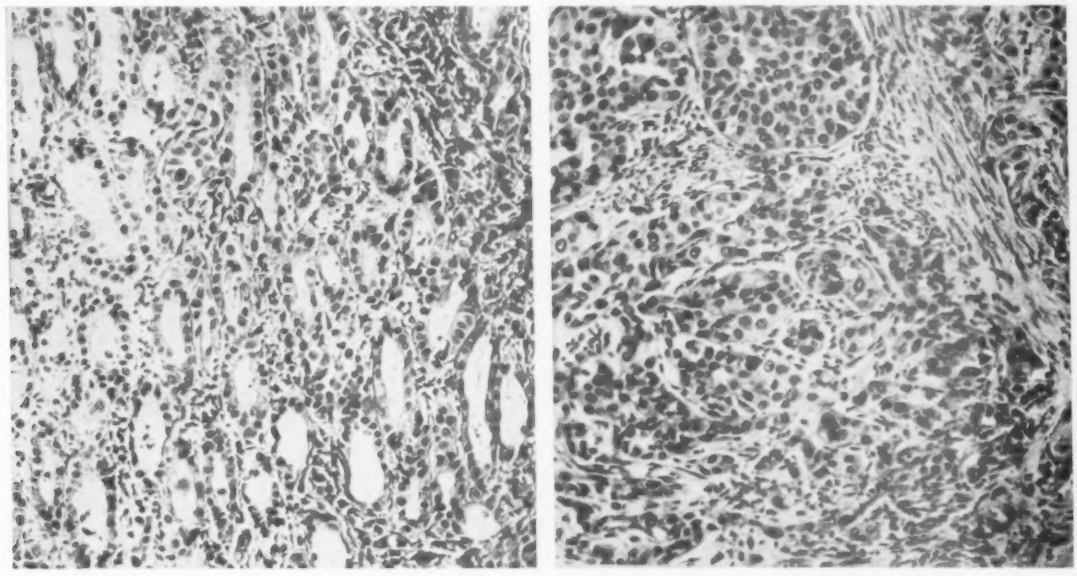
Heart: The pericardial sac was dry and there were no adhesions. The heart was not enlarged, there was no increase in epicardial fat, the endocardial surfaces and appendages were smooth and glistening, the chordae tendinae showed no scarring. The myocardium was pale red and exhibited no other changes. The coronary vessels appeared natural. The aorta was elastic, not dilated, and showed a few scattered atheromatous deposits in its intima.

Liver: Was normal in size, its capsule was thin and glistening. Upon section, there was evidence of focal fatty change and moderate congestion. Multiple sections revealed no focal lesions. The gallblad-

der, bile ducts, and portal vein showed no abnormalities.

Spleen: Was small in size, its capsule smooth and tense. Upon section the organ was soft. The Malphigian bodies were barely visible.

Gastrointestinal Tract: The esophagus appeared natural. The stomach contained a considerable quantity of grayish-green flaky fluid. Its mucosa appeared natural. No focal lesions were noted. The small and large intestines revealed no visible changes.



*a* *b*

Fig. 4. Contrasting photomicrographs of different parts of the same tumor showing an alveolar pattern in one (*a*) and a squamous epithelial arrangement in the other (*b*). In other fields the tumor grew in medullary fashion and exhibited no particular differentiation.

Pancreas: Normal in size, pale yellow, fairly firm and on section revealed no visible changes.

Adrenals: Appeared natural.

Kidneys: Normal in size and the capsules stripped readily revealing a finely granular, dark red surface. There was no reduction of the cortex. The calyces and pelves appeared natural. In the cortex of the right kidney there were two small, firm, yellowish nodules, the larger measuring just under 0.5 cm., the other slightly smaller. These nodules resembled the tumor mass described above. The ureters were patent. The bladder was distended and on section its mucosa was pale. The area of the trigone was slightly hyperemic and no focal lesions were noted.

Prostate: Normal in size, firm, and on multiple section revealed no obvious changes.

Thyroid: Removal of pieces of thyroid tissue from both lobes revealed it to be firm. Cut section showed colloid containing follicles. No focal lesions were noted.

Head: Not examined.

*Microscopic Examination.*

Tumor: Sections showed a highly cellular new growth. The tumor cells were predominantly large, round or polygonal shaped, but showed wide variations in shape as well as size. Nuclei were large, pale staining and there were numerous bizarre mitotic figures. Many cells showed division by fission; their cytoplasm was faintly eosinophilic, scant in amount, granular and poorly defined. The cells were supported by a fine fibrous reticulum and were grouped in fine cords or strands. In places, they assumed small, whorl-like groupings. Other sections showed them widely separated by dense areas of collagenous tissue. Several loosely arranged fibrous tissue septa were seen, bearing infiltrations of lymphocytes. One large focal infiltration of lymphocytes and polynuclear cells in an area of necrosis was seen in the tumor tissue. No prickle cells were found.

One section of the tumor showed definite formation of alveoli (Fig. 4, *a*), their lumina containing traces of eosinophilic material of a homogeneous appearance. Intracellular evidence of secretion was lacking. Another field in the same section showed a definite epithelial pattern of a squamous type (Fig. 4, *b*).

Sections through nerve trunks of brachial plexus showed infiltration of perineural lymphatics by tumor cells (Fig. 5). One section through one of the cervical ganglia revealed extensive infiltration by tumor cells (Fig. 6).

Sections through ribs showed cartilage and connective tissue caught in the tumor tissue, with pressure atrophy of the cartilage.

Reticulum stains (method of Foot and Foot) revealed striking proliferation of reticulum fibers with

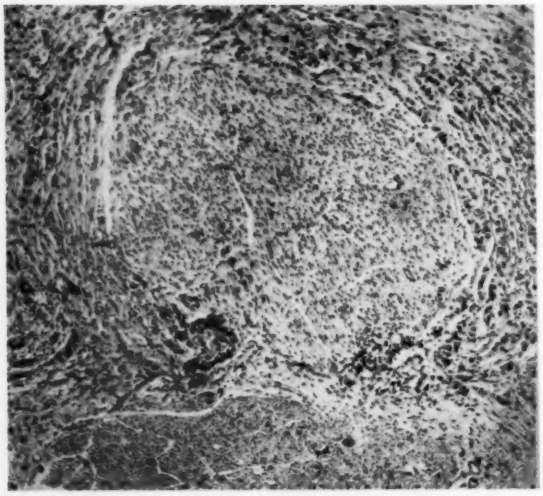


FIG. 5. A low power photomicrograph of a section through a part of the brachial plexus showing tumor cell invasion of a nerve trunk.

condensation into broad bands of collagen, which seemed to space the tumor cells more widely than in the zones of mere reticulum fiber proliferation.

Lungs: Many blocks of tissue taken from the right upper lobe showed diffuse emphysema, patchy collapse, moderate cylindrical bronchiectasis, and evidence of widespread aspiration of gastric contents. Sections including the right visceral pleura, which appeared thickened grossly, showed diffuse permeation of the pleural tissue by tumor cells similar to those seen in the chief tumor mass. In places, they extended for a short distance into the lung septa, but they were found nowhere else (Fig. 7).

Heart: Myocardial fibers appeared fragmented and rather poorly preserved; the striae were not well seen. Nuclei showed a mild degree of bipolar pigmentation. Coronary vessels appeared fairly well preserved.

Aorta: Intima and media showed a mild deposition of atheromatous substance.

Liver: Cell outlines were poorly preserved and cytoplasm appeared to be undergoing parenchymatous degeneration. There was a mild degree of fatty change. Portal space structures appeared essentially normal.

Spleen: Pulp was congested. Malpighian corpuscles were well preserved.

Kidney: Glomeruli showed simplification of tufts and slight thickening of capsular membrane. Hyalinized glomeruli were moderately numerous. Tubular epithelium showed focal areas of degeneration and desquamation. Smaller arteries and arterioles showed a moderate degree of sclerosis. There was one focal, well-localized area of tumor cells identical in appearance to the cells seen in the primary tumor mass. There was no invasion of the surrounding renal parenchyma.

Pancreas: Appeared essentially normal.

Prostate: Glandular epithelium showed focal areas of hyperplasia. Numerous corpora amylacea were present.

Testicle: Appeared essentially normal.

Thyroid: Acini were generally large, lined by low cuboidal or flattened epithelium and filled with a pale homogeneous colloid. There was an irregular, widespread fibrosis. Vessel walls showed sclerotic changes. A small focus of normal parathyroid tissue was seen in the periphery of the section.

*Final Pathologic Diagnoses:* Carcinoma of the right superior pulmonary sulcus (Pancoast) of unknown origin with extension to the first and second ribs, transverse processes and bodies of the seventh cervical, first and second thoracic vertebrae. Metastasis to the pleura and right kidney. Caseous tuberculosis (Ghon lesion), right lower lobe. Lobular pneumonia, bilateral. Patchy emphysema and atelectasis. Terminal aspiration of gastric contents. Kidneys: Mild arteriolosclerosis. Tumor metastasis. Tubular degeneration. Prostate: Focal adenomatoid hyperlasia. Thyroid: Mild interstitial fibrosis. General: Atrophy of the right forearm and hand. Healed biopsy scar, right supraclavicular fossa.

*Comment.* While the autopsy incision did not permit removal and local examination of the structures of the nasopharynx and larynx, there was no clinical symptom

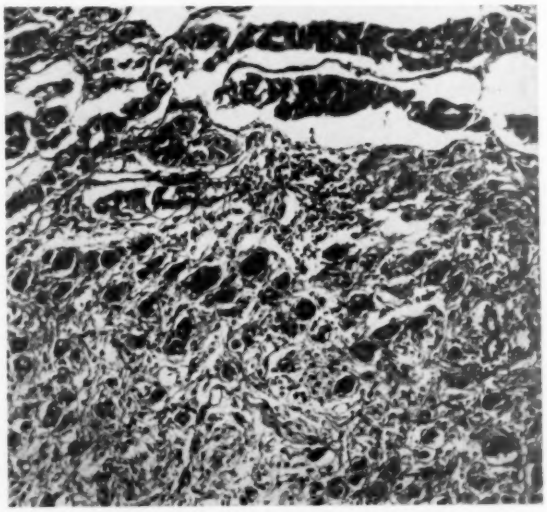


FIG. 6. A high power photomicrograph of a section which included a cervical ganglion showing large ganglion cells in the lower half of the section, and cords of tumor cells in the edge of the ganglion and filling periganglionic lymphatics or tissue spaces above (stain after Foot and Foot).

or sign detectable to suggest a primary lesion in those areas. The trachea was examined as far as the hyoid cartilage and it was possible to remove almost the entire tumor. Those adjacent epithelial structures which were examined revealed no tumor. It is particularly worth emphasizing that the apex of the lung was attached only by adhesions to the tumor and that the spread of the tumor cells on the pleura was limited to a thin plaque about $4 \times 5 \times 0.5$ cm. The metastatic nodules in the kidney are of little consequence beyond suggesting that the convulsive episode noted during the patient's hospital stay may have been due to a tumor metastasis. The finding further supports Pancoast's[11] observations that metastases in this type of tumor are unusual, late, and scanty.

The histological picture of this tumor is interesting. While most sections revealed a disorderly, highly bizarre, cellular pattern, many sections showed a good deal of glandular pattern. Fortunate sections which included nerves or ganglia demonstrated clearly how this tumor invaded the nerves, producing atrophy and destruction quite adequate to account for the palsy and wasting described in life, as well as the disturbances in the occulo-sympathetic reflex pathway.

In view of the limitations of the necropsy, one can only conjecture on the source of this tumor. In any event the weight of evidence seems to be against an intrapulmonary origin. In this connection it should be emphasized that the tumor exhibited its capacity to grow in the deep cervical tissue, destroying such resistant structures as cartilage, bone and muscles, and though attached to the apex of the lung it invaded only the pleura for a negligible distance.

There is adequate evidence to support the proposition that pulmonary neoplasms or spreading chronic inflammatory disease may extend beyond the apex of the lung and compromise the surrounding soft and bony tissues. It is pertinent to mention in this regard Sergent's[12] studies of patients

Fig. 7. A low power photomicrograph of a section through the apex of the right lung including the pleural plaque referred to in the text. Note the flat deposit of tumor cells in the visceral pleura and the invasion of one of the interlobular septa for a short distance.

with advanced apical phthisis exhibiting the Horner syndrome due apparently to extension of inflammatory tissue to the occulo-sympathetic nervous pathway. Furthermore, it is not inconsistent with the known behavior of metastases to postulate their capacity to expand, once planted in the tissues of the superior pulmonary sulcus, with subsequent development of the syndrome described by Pancoast. Tobías,[14] apparently unaware of Pancoast's report, described in the same year, under the title "sindrome ápico-costo-vertebral doloroso por tumor apexiano" 4 cases of pulmonary cancer and one of gastric carcinoma with a metastasis to Virchow's node producing a similar clinical picture.*

Is it possible to rule out a branchiogenic origin in some cases? The difficulty lies in not being able to rule in such an origin. For even an autopsy may not uncover a primary new growth which might be the source for a metastasis in the region where

* Since this paper was submitted for publication, Frost and Wolpaw have described Pancoast's syndrome occurring in an instance of intrathoracic sympathoblastoma (Frost, T. T., and Wolpaw, S. E. Intrathoracic sympathoblastoma producing the symptomatology of a superior pulmonary sulcus tumor (Pancoast). *Am. J. Cancer*, March, 1936, *26*, 483–492).

branchiogenic carcinoma might also arise to produce the Pancoast syndrome. Writers[1,3,6,8] on the subject of branchiogenic carcinoma recognize the difficulty in proving their diagnoses. It is true that squamous cell epithelioma is the type generally reported in such cases. However, some benign lesions like branchial cysts and fistulas have been described[6] as containing in their walls mucous glands and ciliated columnar epithelium. In a recent study of malignant epithelial tumors occurring in the neck, Oliver[9] includes 2 cases of adenocarcinoma considered probably of branchial origin. Therefore it does not seem impossible for those primary superior pulmonary sulcus tumors which spring from embryonal remnants to exhibit at one time squamous cells and at another a glandular pattern. If this is true the histological appearance cannot be used to determine the source of the tumor.

It seems best at present in cases like these to withhold judgment as to their origin and to recognize their clinical import. Too much emphasis cannot be placed upon the need for thorough local, systemic, and roentgenologic investigation of the base of the neck in patients exhibiting persistent pain and other symptoms referable to involvement of the brachial plexus or the inferior cervical ganglia.

## SUMMARY AND CONCLUSIONS

1. The clinical and post-mortem findings are reported in the case of an adult white male, aged forty-seven, who exhibited in life the early development of Horner's syndrome, exquisite pain referable to the right brachial plexus, atrophy of the right upper extremity, a slowly expanding tumor in the right supraclavicular fossa and roentgenographic evidence of destruction of the adjacent first and second ribs, portions of the sixth and seventh cervical vertebrae and the lateral processes of the first and second thoracic vertebrae.

Necropsy revealed a pleomorphic epithelial new growth confined for the most part to the deep tissues of the neck with involvement of the carotid sheath, the brachial plexus, and the bones mentioned above. Pulmonary involvement consisted of a thin plaque-like extension of tumor cells to the visceral pleura at the right apex. Two tiny metastatic nodules were found in the right kidney. No tumor deposits were found anywhere else.

2. The origin of this tumor is discussed and the evidence is considered to support an extrapulmonary source. The possibility of origin from a branchial vestige is acknowledged but the difficulties in establishing this diagnosis cannot be overcome in this instance because of autopsy limitations.

## REFERENCES

1. CARP, L., and STOUT, A. P. Branchial anomalies and neoplasms. *Ann. Surg.*, 1928, *87*, 186–209.
2. CLARKE, B. E. Superior pulmonary sulcus tumor (Pancoast). *Am. J. Path.*, 1934, *10*, 693.
3. EWING, J. Neoplastic Diseases. Third edition. W. B. Saunders Co., Philadelphia, 1931.
4. FRIED, B. M. Bronchiogenic cancer; treatment with roentgen rays. *Am. J. Cancer*, 1934, *20*, 791–806.
5. FRIED, B. M. Bronchiogenic cancer combined with tuberculosis of the lungs. *Am. J. Cancer*, 1935, *23*, 247–266.
6. HYNDMAN, O. R., and LIGHT, G. The branchial apparatus. *Arch. Surg.*, 1929, *19*, 410–452.
7. JACOX, H. W. Superior pulmonary sulcus tumor. *J. Am. M. Ass.*, 1934, *103*, 84–87.
8. MCWHORTER, J. E. Malignant epithelial tumors of the neck of unknown origin. *Ann. Surg.*, 1929, *90*, 1–14.
9. OLIVER, R. L. Malignant epithelial tumors of the neck. *Am. J. Cancer*, 1935, *23*, 16–44.
10. PANCOAST, H. K. Importance of careful roentgen-ray investigations of apical chest tumors. *J. Am. M. Ass.*, 1924, *83*, 1407.
11. PANCOAST, H. K. Superior pulmonary sulcus tumor. *J. Am. M. Ass.*, 1932, *99*, 1391–1396.
12. SERGENT, E. Nouvilles études cliniques et radiologiques sur la tuberculose, et les maladies de l'appareil respiratoire. Maloine, Paris, 1926.
13. STEINER, P. E., and FRANCIS, B. F. Primary apical lung carcinoma. *Am. J. Cancer*, 1934, *22*, 776–785.
14. TOBÍAS, J. W. Sindrome ápico-costo-vertebral doloroso por tumor apexiano. *Rev. méd. latino-am.*, 1932, *17*, 1522–1556; *18*, 57; 151; 304.

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# CHOLECYSTOGRAPHIC FINDINGS FOLLOWING CHOLECYSTOSTOMY*

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IT HAS been an accepted fact that the majority of our surgical colleagues have favored, for many years, the removal of the gallbladder when the diagnosis of a diseased gallbladder has been made. Their decision has been substantiated, in part, by the patient's apparent freedom from clinical symptoms, insofar as further surgical interference is seldom necessary. In recent years, our internists have observed an increase in the percentage of cholecystectomized patients in their practice, presenting gastrointestinal symptoms. The internists recite the apparent comfortable existence, so far as gastrointestinal distress predominates, for an indefinite period of time, in those selected cases that have been subjected to a cholecystostomy. In contradistinction to present roentgenological knowledge, the internists state that the roentgenologist has made a report of normal function for some gallbladders that previously had surgical drainage. Consequently, the advisability of removing all diseased gallbladders had become a moot question.

Since the advent of the Graham test in 1924 for the visualization of the gallbladder, the preoperative diagnosis of the gallbladder has been enhanced. In 1927, Spurling and Whitaker[6] examined the gallbladders of 12 patients, by means of the Graham test, that had previously been subjected to surgical drainage. Their conclusions, made at that time, substantiate the surgeons' contention that the removal of the diseased gallbladder is the operation of choice. Moore[3] in 1928 agreed with the conclusions of Spurling and Whitaker. In recent years, the technique for the administration of the gallbladder dye and the examination of the gallbladder has undergone many alterations for the perfection of this type of roentgenographic examination. Acknowledging the import of the mitigating evidence presented by the internists, we sought further information regarding the gallbladders of cholecystostomized patients to substantiate the results of Spurling and Whitaker.[6]

There is an abundance of scientific reports and protocols in the literature, which we do not deem necessary to review, demonstrating the use of the gallbladder in the process of digestion. Numerous investigators, among them Rous and McMaster,[5] have proved and substantiated each other, that the gallbladder has a marked power of concentrating the bile carried to it from the liver. Added information, presented by many investigators,[1,2,4,7,8,9,10] proves conclusively that the bile is stored in the gallbladder and emptied into the duodenum, according to the physiologic demands of digestion and the ingestion of fats and proteins. We affirm that many thousands of cholecystectomized patients have enjoyed good health since the operation, which permits the inference that the gallbladder is not essential to health. We deny that all cholecystectomized patients have enjoyed good health since the operation. We question the opinion that all gallbladders that have been subjected to surgical drainage do not have normal physiological function postoperatively.

Perusal of the hospital records revealed about 200 cholecystostomies during the past fifteen years. We had considerable difficulty in locating some of these patients, due to change in address or death. We were successful in recalling 28 patients to the de-

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TABLE I

| Case No. | Sex | Age | Preoperative Cholecystograms | Time Since Operation | Surgical Diagnosis | Gallbladder Drained | Symptoms since Operation | Recent Cholecystograms |
|---|---|---|---|---|---|---|---|---|
| 1 | M | 45 | None | 8 mo. | Gallstone | 2 wk. | None | ★ |
| 2 | F | 50 | None | 7 yr. | Gallstones | 3 wk. | Recent colic | Pathological |
| 3 | F | 55 | (a) None<br>(b) None | 8 yr.<br>6 yr. | Gallstone<br>Gallstone | 3 wk.<br>3 wk. | Slight distress<br>None | Normal function, gallstone |
| 4 | F | 66 | None | 5 yr. | Gallstone | 3 wk. | None | ★ |
| 5 | F | 50 | None | 20 yr. | Gallstones | 2 wk. | Vague gastrointestinal distress | ★ |
| 6 | F | 45 | None | 3 yr. | Gallstone | 2½ wk. | None | Normal function Gallstone |
| 7 | F | 40 | Failed to visualize | 3½ yr. | Gallstone | 2 wk. | Occasional colic (subacute) | ★ |
| 8 | M | 43 | None | 14 yr. | Gallstones | 3 wk. | None | ★ |
| 9 | M | 45 | None | 8½ yr. | Gallstone | 2 wk. | Gallbladder distress once | ★ |
| 10 | F | 32 | Normal | 15 mo. | Gallstone | 3 wk. | Occasional pain back | ★ Adhesions, lower pole |
| 11 | F | 50 | Mottled Gallstones | 16 mo. | Gallstones | 3½ wk. | Nausea first year; flatulence | ★ Conical deformity of lower pole; gallbladder in two loculi |
| 12 | F | 65 | None | 42 mo. | Gallstones | 3 wk. | None | ★ |
| 13 | F | 47 | None | 13 yr. | Gallstones | 4 wk. | Pain right side, past 7 years | ★ |
| 14 | F | 35 | Gallstones | 14 mo. | Gallstones | 4 wk. | Nausea and emesis; no pain | ★ Small residue |
| 15 | F | 48 | Pathological | 2 yr. | Gallstone | 11 days | None | ★ |
| 16 | F | 50 | None | 5½ yr. | Gallstones | 4 wk. | None | Pathological |
| 17 | F | 49 | None | 8 yr. | Gallstone | 2 wk. | None | ★ Definite residue |
| 18 | F | 46 | Pathological Mottled | 3½ yr. | Gallstones | 8 days | None | ★ |
| 19 | M | 49 | None | 14 yr. | Gallstone | 10 days | None | ★ Definite residue |
| 20 | M | 45 | Indistinct | 28 mo. | Gallstone | 2 wk. | None | ★ Residue. Small |
| 21 | F | 38 | Pathological | 12 yr. | Empyema | 3 wk. | None | Pathological |
| 22 | F | 40 | None | 3 yr. | Empyema | 2 wk. | None | ★ |
| 23 | F | 50 | Indistinct | 9 yr. | Empyema | 3 wk. | None | Pathological; gallstone |
| 24 | F | 45 | None | 9 yr. | Empyema | 12 days | None | ★ |
| 25 | M | 68 | None | 7½ yr. | Gallstone | 6 wk. | None | Pathological |
| 26 | M | 78 | None | 10 yr. | Gallstone | 7 days | None | Pathological |
| 27 | F | 45 | None | 3½ yr. | Gallstone | 2 wk. | Occasional gallbladder colic, not severe | ★ |
| 28 | F | 59 | None | 8 yr. | Gallstones | 10 days | None | Pathological |

★ Demonstrates a gallbladder that fills and empties normally and the shadow is homogeneous.

partment for the purpose of making cholecystograms. It is not a routine procedure to make intravenous injection of the gallbladder dye in our department. All of these 28 patients were examined by the oral method. The dye used was keraphen B, heavy, and was ingested after the evening meal. Cholecystograms were made fourteen and sixteen hours later. After the sixteen hour examination a fatty meal consisting of 8 ounces of half milk and half cream, plus the yolk of one egg, was given to the patient. Twenty hours after the ingestion of the dye another series of cholecystograms was made to determine the ability of the gallbladder to empty itself. Table 1 summarizes the data on each case.

Seven of the 28 patients were males, ranging in ages from forty-three to seventy-eight years. The balance were females, viz., 21, between the ages of thirty-two and sixty-six. The gallbladders were drained at the time of operation from eight days to four weeks. The time elapsed between the cholecystostomy and the recent cholecystographic examination was from eight months to twenty years. Nineteen of the patients gave no history of any symptoms referable to the gallbladder or the gastrointestinal tract since the operation. Nineteen patients responded normally to gallbladder visualization. These are not the same 19 patients who had a negative history for gallbladder trouble or gastrointestinal distress since the cholecystostomy. Seven patients had definitely pathological gallbladders, 2 of which have been recently removed.

## DISCUSSION

In the discussion of this problem, we have intentionally not described the anatomy of the gallbladder. The literature is abundant with this information from competent investigators. After the ingestion of the opaque dye a nondiseased gallbladder will present a homogeneous shadow in the cholecystogram. The formation of the shadow, as well as its concentration has, as one of its factors, the mucous membrane of the gallbladder. Experimental data have been presented by Spurling and Whitaker showing that a denuding of the epithelium of the mucous membrane tends to alter the concentration of the shadow. The ability of the gallbladder to function by filling and emptying itself has as one of its factors the musculature in its walls. Fibrosis or sclerosis of the walls would inhibit the rhythmic effectual contractions to empty itself of its contents.

Until recently, we have been impressed with the results of Spurling and Whitaker, concluding therefrom that any gallbladder that was subjected to surgical drainage because of the presence of gallstones or infection was, per se, sufficiently damaged so that physiological function of the organ postoperatively was not to be entertained. Case 7, in Table 1, has a preoperative cholecystographic report that the gallbladder failed to visualize. The recent roentgenographic examination, made three and a half years postoperatively, presents a cholecystographic report that the gallbladder fills and empties normally and that the shadow is homogeneous. Case 11 had a preoperative cholecystographic report that showed a mottled gallbladder shadow due to gallstones, whereas the recent cholecystographic report, made sixteen months postoperatively, presents a gallbladder that fills and empties normally and has a homogeneous shadow, although there is a conical deformity involving the lower pole of the gallbladder, probably due to previous surgical drainage. There are 3 other cases in the table having pathological preoperative cholecystographic reports and normal postoperative cholecystographic reports.

## SUMMARY

1. Surgical colleagues favor the removal of the diseased gallbladder, because it is not essential to health. Internists favor cholecystostomy in selected cases, inasmuch as the gallbladder may have its normal physiological function after surgical drainage.

2. Cholecystograms were made on 28 patients following cholecystostomy. There

was a varying interval of time from the operation to the roentgenographic examination. Nineteen of these patients, or approximately 68 per cent, showed a normally functioning gallbladder with a homogeneous shadow.

3. Seven patients had pathological gallbladders in the postoperative cholecystograms. Two of these have been confirmed by recent surgical interference, and a cholecystectomy performed.

4. Two of the 28 patients in the postoperative cholecystograms had gallbladders that filled and emptied normally, but gallstones were present.

5. Several of the gallbladders had a residue after the fatty meal, but the shadow of the residue was less dense than that previous to the meal; and the size of the gallbladder had become smaller denoting contraction of the walls of the organ to expel its opaque contents.

6. Finally, we cannot agree with the concept of Spurling and Whitaker: "That the drainage of a diseased gall bladder with the expectation that it will regain its normal function is not only a futile procedure, but one that endangers the future health of the patient."

We wish to express our sincere appreciation and thanks to those members of the Medical Staff of St. Luke's Hospital, especially to Dr. Harry E. Mock, who made our task of obtaining clinical material for the necessary examinations less difficult.

Also, we wish to acknowledge with sincere thanks and appreciation the donation of the gallbladder dye, keraphen B, heavy, by the Picker X-Ray Corporation of New York City, whose cooperation made this investigation possible.

## REFERENCES

1. BOYDEN, E. A. The effect of natural foods on the distention of the gall bladder, with a note on the change in pattern of the mucosa as it passes from distention to collapse. *Anat. Rec.*, 1925, *30*, 333–364.
2. BOYDEN, E. A. A study of the behavior of the human gall bladder in response to the ingestion of food; together with some observations on the mechanism of the expulsion of bile in experimental animals. *Anat. Rec.*, 1926, *33*, 201–255.
3. GRAHAM, E. A., COLE, W. H., COPHER, G. H., and MOORE, S. Diseases of the Gall Bladder and Bile Ducts. Lea and Febiger, Philadelphia, 1928.
4. MCMASTER, P. D., and ELMAN, ROBERT. On the expulsion of bile by the gall bladder; and reciprocal relationship with sphincter activity. *J. Exper. Med.*, 1926, *44*, 173–198.
5. ROUS, P., and MCMASTER, P. D. The concentrating activity of the gallbladder. *J. Exper. Med.*, 1921, *34*, 47–73.
6. SPURLING, R. G., and WHITAKER, L. R. End-results of cholecystostomy as shown by the cholecystogram. *Surg., Gynec. & Obst.*, 1927, *44*, 463–467.
7. WHITAKER, L. R. Experiences with cholecystography, including observations on the function of the gallbladder. *J. Am. M. Ass.*, 1926, *86*, 239–243.
8. WHITAKER, L. R. The mechanism of the gall bladder. *Am. J. Physiol.*, 1926, *78*, 411–436.
9. WHITAKER, L. R. *Boston M. & S. J.*, 1926, *194*, 374.
10. WHITAKER, L. R., and BOYDEN, E. A. Observations on the function of the gall bladder. *Am. J. Physiol.*, 1926, *76*, 199.

# DIAPHRAGMATIC HERNIA AND DIVERTICULUM OF THE ESOPHAGUS

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A SERIES of seven cases of nontraumatic diaphragmatic hernia was reported in a previous article,[4] in which a more or less detailed description of the condition was given, the literature was reviewed, and the incidence, etiology, symptomatology, diagnosis, and treatment were discussed. A résumé of that article might not be inappropriate at this time.

*Incidence.* In the cases reported to date, the incidence is 1 in 3,733 cases examined. This is undoubtedly an erroneously low figure, as some of the larger clinics examine gastrointestinal cases in the upright position only. In Carman and Fineman's series[3] and in the reports of Béclère,[1] MacMillan,[6] and Rendich,[9] quoted by Pancoast and Boles,[8] the incidence is 1 in 224 cases, which is probably more nearly correct.

*Etiology.* The age in the cases reported varies from five to seventy-five years. The condition is more frequent in females. Bund[2] believed that congenital abnormal development of the omental bursa is the principal causative factor. Richards[10] states that interference with the normal closure of the pleuroperitoneal membranes must be considered in the etiology. There is no doubt that these hypotheses are true, as there appear to be two types of this lesion, namely, congenital and acquired. The latter is the more common, and Healy's theory of indirect trauma[5] is in all probability correct. The hiatus is the only muscular portion of the diaphragm and hence the most easily distensible. Increases in intra-abdominal pressure, such as result from straining at stool, the second stage of labor, the paroxysms of pertussis, and other causes exert considerable pressure in all directions, and the weakest link in the anatomical chain is the first to break. Moore[7] believes that all such lesions are of the congenital type.

*Symptomatology.* The smaller hernias give no symptoms. The most common complaints in those giving symptoms are substernal pain, regurgitation, and epigastric distress on assuming a recumbent position. The most frequent erroneous diagnosis is gallbladder disease. The condition may simulate peptic ulcer or cardiovascular or pulmonary disease.

*Diagnosis.* The diagnosis is rarely made clinically. Careful roentgenoscopic examination in the upright, prone, supine, Trendelenburg, and right and left oblique positions will usually reveal the condition when it is present.

*Differential Diagnosis.* The following conditions must be considered: (1) cardioesophageal relaxation; (2) diverticulum of the lower end of the esophagus, particularly that portion just beneath the diaphragm; (3) cardiospasm; (4) hour-glass stomach; (5) carcinoma of the lower esophagus; (6) perforation of the esophageal wall with pseudodiverticular formation; (7) thoracic stomach resulting from a congenitally short esophagus.

*Treatment.* In cases with symptoms of only moderate severity, hygienic and dietetic measures usually suffice. Adequate time should be taken for meals and thorough mastication should be practiced. The patient should eat sparingly of light, easily digested food. Fluids are not restricted. Rest periods after meals should be in the upright or at most in a semirecumbent position. The supine position should not be assumed immediately after meals. Conditions conducive to increases in intra-abdominal pressure should be avoided. When the symptoms are severe and do not respond to the treatment outlined, surgical intervention should be considered. The operation is indeed a major one, and the operative risk should not be overlooked. An outline of the technique of operation is given in the original paper.

## DIVERTICULA OF THE ESOPHAGUS

Diverticula of the esophagus are most common in the upper third, next in the lower third, and least common in the middle third. These are usually classified as pulsion or pressure diverticula, that is, pressure is exerted on the esophageal wall from within, and traction diverticula, in which extrinsic esophageal pathology results in adhesions, the contraction of which causes a pit to form on the endesophageal

wall, and further contraction results in a definite sacculation. There is no doubt that in the traction type, pulsion is an important factor once the pit has been formed, and because of this a third type is called pulsion-traction. The pulsion type is by far the most numerous, and occurs at the inlet of the esophagus where a muscular deficiency tends to exist and where anomalies in closure of the brachial clefts may play a part. Traction diverticula are primarily the result of mediastinal pathology, usually glandular in nature, and occur most frequently in close proximity to the left bronchus. The traction type is usually seen roentgenoscopically as a wedge or funnel shaped mass of the opaque medium; while the pulsion or pressure type is seen as a smooth, rounded mass. The opening in either type may be small or large, slit-like, ovoid, or circular. The constant finding, however, is that the sac, or at least the major portion of it, lies below the opening, the reason for this being obvious.

*Symptoms.* When small and easily emptied there are usually no symptoms, but as the sac becomes larger a definite train of symptoms ensues, practically all of which are due to obstruction and stagnation of ingested food. These may be enumerated as follows:

1. Choking sensation.
2. Regurgitation of food during a meal.
3. Change of voice tone.
4. Inability to sleep comfortably unless sac is empty.
5. Dysphagia and dyspnea.
6. Regurgitation of food eaten hours or days previously.
7. Pain and feeling of pressure in the chest.
8. Obstruction to the passage of food.
9. Sternal burning.
10. Constant feeling of foreign body in the throat.
11. Foul breath.
12. Acute esophagitis with a resulting mediastinitis or abscess.

*Diagnosis.* The diagnosis may be made on a history of any or all of the above symptoms, by the use of the esophagoscope, or a stomach tube, though in using the tube it should be borne in mind that a thin-walled sac may be punctured, and that the length of the esophagus varies with the body habitus. The simplest and easiest way to make the diagnosis is with the roentgenoscope. By this means it is possible to visualize the sac and accurately determine its size, shape, and location. Differential diagnosis must be made from carcinoma, cardiospasm which is sometimes associated with a diverticulum of the lower esophagus, and benign cicatricial strictures.

Carcinoma, a progressive condition, may be differentiated by the irregularity of the lumen, and the history of difficulty in swallowing over a comparatively short period of time. The patient's story is somewhat typical: inability to swallow solids such as meat, and the elimination of this article of food from the diet, with subsequent eliminations through the series of solid and semisolid foods until the patient is ingesting liquids only, and, finally, complete obstruction. This, together with a rapid loss of weight and strength, due partly to starvation and partly to toxemia, and the roentgen picture of irregularity of the esophagus, eccentric lumen, and only moderate dilatation above the constriction, gives a rather definite picture of malignancy.

Cardiospasm, an intermittent condition, exists over a long period of time, usually years. The attacks may be precipitated by ice water, hot water, various articles of diet, or other causes. Primary cardiospasm is due to failure of the central inhibitory influence controlling contraction of the cardia, atony of the muscular coats of the esophagus, or a combination of the two foregoing causes brought on by a paralysis of the vagus, primary esophagitis and kinking at the esophageal hiatus, or contraction of the hiatus itself. The condition is most common in neurotics and females and occurs at any age. Anemia is also stated to be a cause. In cardiospasm the esophagus is considerably dilated and there is marked

retention of food. Regurgitation may occur several hours after partaking of food and not unusually during the night after the patient has assumed a recumbent position. These returns contain no HCl or gastric enzyme, and the food is in the form in which it was swallowed, indicating that the regurgitation is esophageal and not gastric in origin. This is true also of diverticula.

Cicatricial contractures follow the ingestion of some caustic such as lye, phenol, iodine, and so forth. A history of such an accident is usually obtained. Roentgenologically this condition is generally stationary, in contradistinction to the intermittent cardiospasm and the progressively downward course of carcinoma. The symptoms of benign stricture are those dependent on obstruction, and are present in direct proportion to the degree of obstruction, which in turn depends upon the concentration of the caustic and therefore destruction of the esophageal mucous membrane, resulting in a greater production of scar tissue.

*Treatment.* The treatment is essentially surgical. Small diverticula which give no symptoms require no treatment. In those giving symptoms, the patient's health and strength should be built up so that he may withstand the severity of the necessary operative procedure. Rectal feeding and feeding through a stomach tube may be resorted to. In the ordinary diet semisolids and fluids of high nutritive value should be employed, and only small amounts should be swallowed at one time. Other measures include frequent washings of the esophagus with water, which help to prevent fermentation and decomposition.

### CASE REPORT*

R. B., white, female, aged fifty-eight, referred by Dr. J. J. McHale. Past and family history irrelevant. Present illness began several years ago with severe attacks of pain in the upper abdomen. These came on at increasingly frequent intervals and required morphine for relief. The attacks usually followed the ingestion of food and there was considerable belching with acid eructations. A clinical diagnosis of gallbladder disease was made elsewhere, but was not confirmed by roentgen-ray studies of the gallbladder and gastrointestinal tract which were made at the time.

Physical examination revealed a well-nourished and well-developed white female. The head, eyes, ears, nose, throat, heart, lungs, abdomen, genitalia and extremities were essentially negative. Blood pressure was: 180 systolic, 110 diastolic. The urine showed a slight trace of albumin. The only complaint was of severe pain in the epigastrium.

Fig. 1

Roentgenoscopic and roentgenographic examination of the gastrointestinal tract (Fig. 1) showed that the heart and aorta were of the hypertensive type. The lungs were within normal limits roentgenoscopically. The esophagus showed a definite pouch at its middle third which filled and emptied itself as the patient swallowed. Considerable cardioesophageal relaxation was noted in the prone position. There

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was also a definite sacculation above the diaphragm on the left side which had free communication with the stomach. This was separate and distinct from the esophagus and was very probably a herniation of the stomach through the esophageal hiatus. The stomach was of the steerhorn type and exhibited normal tonus and normal peristalsis. No gas bubble was seen in the stomach. The pyloric sphincter was patent and functioned well. The duodenum was apparently normal in size, shape, and position, was freely movable, and there was no tenderness in the right upper quadrant. The five hour study showed less than 5 per cent residue, and a gas bubble was seen on the left above the diaphragm in the epigastric region. At this time the head of the barium column had reached the transverse colon. A twenty-four hour study was not made. Conclusion: Diverticulum of the middle third of the esophagus and herniation of the stomach through the esophageal hiatus. Operation (by Dr. John H. Lyons) revealed an opening beside the esophagus which admitted four fingers. This was closed with No. 2 chromic catgut.

*Comment.* This is believed to be the first reported case of a hernia through the hiatus in which a diverticulum of the middle third of the esophagus was a complication.

REFERENCES


1. Béclère. Quoted by Morrison, L. B. Diaphragmatic hernia of the fundus of the stomach through the esophageal hiatus. *J. Am. M. Ass.*, 1925, *84*, 161–163.
2. Bund, R. Ein Fall von rechtsseitiger Hernia diaphragmatica mit Austritt des Magens in den persistierenden Rezessus pneumatoentericus dexter. *Frankfurt. Ztschr. f. Path.*, 1918, *21*, 243–257.
3. Carman, R. D., and Fineman, S. Roentgenologic diagnosis of diaphragmatic hernia. *Radiology*, 1924, *3*, 26–45.
4. Elward, J. F., and Otell, L. S. Nontraumatic diaphragmatic hernia. Am. J. Roentgenol. & Rad. Therapy, 1929, *22*, 535–542.
5. Healy, T. R. Symptoms observed in 53 cases of non-traumatic diaphragmatic hernia. Am. J. Roentgenol. & Rad. Therapy, 1925, *13*, 266–271.
6. MacMillan, A. S. Diaphragmatic hernia. Am. J. Roentgenol. & Rad. Therapy, 1920, *7*, 143–146.
7. Moore. Cited by Elward.
8. Pancoast, H. K., and Boles, R. S. Nontraumatic left diaphragmatic hernia. *Arch. Int. Med.*, 1926, *38*, 633–646.
9. Rendich, R. A. Radiographic examination of the alimentary tract. *J. Radiol.*, 1924, *5*, 124–127.
10. Richards, L. G. Nontraumatic hernia of the diaphragm. *Ann. Otol., Rhinol. & Laryngol.*, 1923, *32*, 1145–1196.

Vol. 36, No. 3

# ECTOPIC STOMACH

## CASE REPORT

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RECENTLY a very unusual case of inguinal hernia came to our attention in the Outpatient Clinic. The rarity of the condition, rather than its difficulty of diagnosis or method of treatment, seems to warrant its report.

J. N., Jewish male, aged sixty-nine, presented himself to our clinic complaining of gastrointestinal upsets of two years' duration. At the time of admission he was troubled with severe vomiting which curiously enough was free of pain or other distress. He had lost approximately 70 pounds in the last year.

On gastrointestinal roentgen examination the esophagus was seen to extend far below the diaphragm into the left lower abdomen. The stomach was normal in size and outline but was displaced to a position low down in the pelvis. At least two-thirds of this organ, together with the duodenum, was contained in a large inguinal hernial sac. A loop of small intestine and a portion of the transverse colon were also found within the sac.

FIG. 1

At six hour examination the stomach showed complete residue. During this examination the patient had been up and about in the ward. Re-examination made with the patient in the recumbent position and his hernia reduced, revealed complete emptying at six hour examination. No intrinsic lesion was found in the gastrointestinal tract.

The hernia was of twelve years' duration and had never been operated upon. At operation the hernia was found to be of simple indirect type.

# BILATERAL FRACTURE OF THE ANATOMICAL NECK OF THE HUMERUS

## CASE REPORT

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THIS case report was thought worthy of a place in the literature because bilateral fracture of the anatomical neck of the humerus is rare, and because the exact manner of fracture production is known. Dr. G. R. Miller, roentgenologist to the Episcopal Hospital, interpreted the films, and Dr. E. P. Pendergrass of the Department of Roentgenology of the University of Pennsylvania, concurred in the diagnosis. This case report is taken from the Surgical Dispensary of the Episcopal Hospital, and from the Surgical Service of the late Dr. A. P. C. Ashhurst.

On June 8, 1932, M. C., a white female, aged fifty-three, entered the Surgical Dispensary complaining of pain and stiffness in both shoulders, more intense on the right side. These symptoms were of ten days' duration and dated back to a fall, at which time the patient became momentarily dizzy and pitched forward to the ground, striking on both forearms flexed at the elbow and held in internal rotation. Healing abrasions along the upper medial surface of each forearm served to support her statement.

Roentgen examination of the right shoulder showed a fracture of the humerus through the anatomical neck (Fig. 1). Roentgen examination of the left shoulder two days later (June 10) revealed the same type of fracture (Fig. 2). Both fractures showed some comminution, with a displacement of the articular surface parallel to the long axis of the shaft on the right side, and at a right angle to the shaft on the left side. She was admitted to the ward for a few days, where Dr. Ashhurst saw her and advised conservative treatment. Movements in the shoulder joints were not restricted in any way, and the patient was told to move her arms as freely as the pain would permit.

Follow-up examination nine months later (March 22, 1933) found the patient satisfied with the result. She complained of some pain in both shoulders in bad weather, more pronounced on the left side. Clinical examination of the right shoulder revealed an arthrodesis of the joint with the position of the humerus shown in Figure 3, yielding an abduction of about 80° with the scapular movement. In the left shoulder (Fig. 4), flexion and abduction were approximately 60°, with normal internal

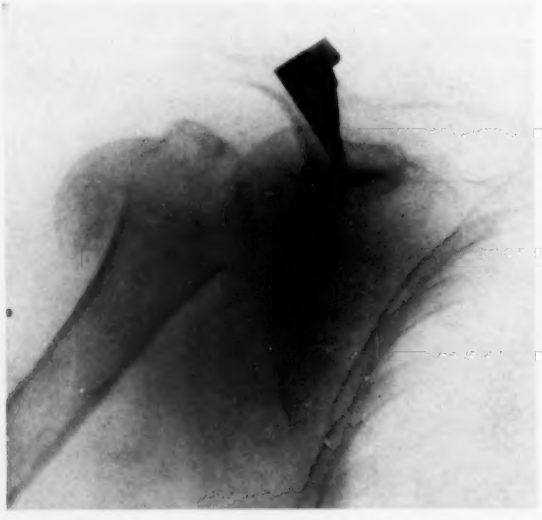

FIG. 1. Right shoulder, June 8, 1932.

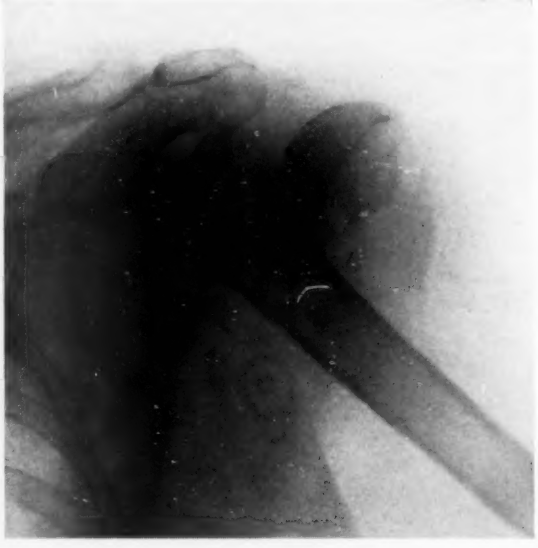

FIG. 2. Left shoulder, June 10, 1932.

Fig. 3. Right shoulder, nine months later.

Fig. 4. Left shoulder, nine months later.

and external rotation. These movements were accompanied by definite coarse grating. She continues to work at her usual occupation of house cleaning and as a domestic.

In an atypical fracture such as this, with the shoulder girdle locked between the arms, one might expect the force to be transmitted through both clavicles and the sternum. If this were the case, the fracture of one or both clavicles might be anticipated. But the acute angle which the clavicle forms with the humerus when the latter is in the flexed position (abducted anterior to the coronal plane) would indicate that the force in each clavicle with attached ligaments is one of tension and not of pressure.

A suggested mechanism of fracture in this case is as follows: With the arms upraised in front to receive the force of the fall, each scapula is rotated and held forward, mainly by the serratus anterior and trapezius muscles. As the force is received on the internally rotated arm, the body is supported by the strong muscles of internal rotation, namely, the latissimus dorsi, pectoralis major and teres major. These muscles create a powerful downward force on the shaft of the humerus, while the head of the bone rests on the glenoid surface, which is now more nearly in the horizontal plane, owing to the anterior rotation of the scapula. A fracture of the anatomical neck is the result.

The displacement of the head on the left side, at a right angle to the shaft, might suggest a complete rupture of the transverse humeral ligament, freeing the long tendon of the biceps from its groove.

The end-result, without operative interference, was thought to be unusually good.

# OSTEOPLASTIC METASTASIS IN PAPILLARY CARCINOMA OF THE BLADDER

## CASE REPORT

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A REASONABLE review of the literature reveals that proved cases of metastases to the bony skeleton from carcinoma of the bladder are rare. Graves and Militzer,[2] reporting 5 cases, suggest that such deposits occur more often than commonly supposed. Ewing[1] states: "Metastases are not common, but have been observed in liver, lung, pleura, kidney, inguinal and axillary nodes." He does not mention skeletal metastases. Kretschmer,[4] in 1922, aroused interest in this subject by reporting 5 cases. Wells[6] in the same year reported a case metastasizing to the sternum. Nicholls[5] reported a case in 1933.

In the 12 cases reported and reviewed 4 were osteoplastic, 2 were osteoplastic and osteoclastic and 6 were osteoclastic. The method of dissemination is apparently either by the blood stream or via the lymphatics.

The following case is presented as an unusual manifestation of osteoplastic metastasis in a case of papillary carcinoma of the bladder.

### CASE REPORT

O. O. (No. 42063), a white male, aged forty-one, occupation railroad mail clerk, was admitted in June, 1932.

*Chief Complaint.* Bloody urination.

*Family History.* Mother died of cancer of the stomach at the age of sixty-nine. Brother died of tuberculosis.

*Past History.* Essentially negative.

*Present Illness.* About three months before admission, bloody urine was noted at end of micturition. No note was made of this blood until two days before admission when blood clots were passed. No history of pain or other symptoms.

*Physical Examination.* June 27, 1932. A well nourished and developed male showed nothing of significance on general physical examination. Kidney and bladder regions negative, as were the genitalia. There was no adenopathy. The prostate was enlarged, regular and soft. The vesicles were not palpable. The urine was bloody.

*Cystoscopic Examination.* A No. 24 McCarthy cysto-urethroscope was passed to the bladder with ease. Nothing of significance was seen in the bladder vault. The left ureteral orifice was visualized and normal. The right ureteric ridge and ureteral orifice was occupied by a flat growth which was infiltrating the bladder. This growth was ulcerating and necrotic in the center. The mass was $2 \times 1.5$ cm. The trigone was otherwise normal, as was the internal sphincter. A specimen was removed for biopsy.

An intravenous pyelographic examination showed no genitourinary disease.

*Laboratory Findings.* Urinalysis, June 28, 1932: Reaction acid; specific gravity, 1.025; color, amber; albumin, heavy trace; sugar, negative; white blood cells, few; red blood cells, many; casts, none. An examination of the blood on June 27, 1932, showed red blood cells, 4,430,000; white blood cells, 8,400; Hb, 80 per cent. Blood chemistry: Non-protein nitrogen, 30 mg. per 100 c.c.; creatinin, 1.6 mg. per 100 c.c.; sugar, 92.2 mg. per 100 c.c.; P.S.P. intravenously, first hour, 30 per cent, second hour, 10 per cent. The Wassermann and Kahn reactions were negative.

*Biopsy Specimen.* Gross description: Biopsy specimen from bladder. Microscopic description: Nests of large oval epithelial cells, with an abundant well-vascularized stroma. Mitosis noted (Fig. 1). Diagnosis: Carcinoma, transitional cell type.

*Treatment.* Irradiation (radium bomb) 40,000 mg-hr. suprapubically over the bladder, and 40,000 mg-hr. posteriorly distributed over a period of three weeks at four hours per day. Distance 10 cm., portals 10 cm. Patient was discharged on August 9, 1932, symptom-free.

Readmission on November 25, 1932, for a recurrence of the terminal hematuria which reappeared about November 1; no other subjective symptoms. Cystoscopic examination on

November 28, 1932, showed an extension of the growth since the last examination. Recommendation, suprapubic cystotomy and implantation of radon seeds. On December 2, 1932, a suprapubic cystotomy was done and 15 gold radium emanation seeds were implanted in the tumor 1 cm. apart, averaging 1.18 mc. each. The patient was discharged on January 10, 1933, cystotomy wound closed, with a recommendation to return in ninety days.

Readmission September 19, 1933.

Cystoscopic examination on October 5, 1933, revealed a recurrence of the malignancy, with thickening of the bladder wall, with areas of necrosis and ulceration. A biopsy showed malignant degeneration.

*Treatment.* Radium irradiation with 30,000 mg-hr. through each of five portals, two anterior, two posterior, one through the perineum at 10 cm. distance.

Patient discharged on November 9, 1933, symptom-free. Advised to return in ninety days.

Readmission March 16, 1934. At this time frequency was severe, and the urine was filled with débris. Cystoscopic examination revealed that the tumor involved the entire right lateral wall of the bladder and right half of the trigone. Ureteral transplantation was advised but refused. Roentgen examination of the pelvis showed marked bony changes, characterized by small islands of heavy density suggestive of metastasis (Fig. 2). These islands were not previously present. The patient was given deep roentgen therapy to the pelvis anterior and posterior, 200 kv., 30 ma., total 1,506 r anterior and 1,586 r posterior. Discharged April 10, 1934.

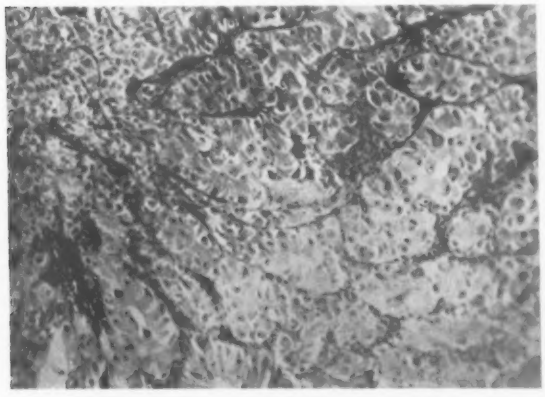

Fig. 1. Photomicrograph showing nests of large oval epithelial cells, with an abundant well-vascularized stroma. Mitosis is noted.

Fig. 2. Roentgenogram of pelvis shows marked bony changes, characterized by many small islands of heavy density.


## SUMMARY

1. An unusual case of osteoplastic skeletal metastasis is presented.
2. The primary lesion was that of a transitional cell-carcinoma of the bladder.
3. A review of the literature reveals only four similar reported cases.


## REFERENCES


1. Ewing, J. Neoplastic Diseases, W. B. Saunders Co., Philadelphia.
2. Graves, R. C., and Militzer, R. E. Bone metastases from carcinoma of the urinary bladder. *J. Urol.*, 1934, *31*, 769–789.
3. Kaufman, L. R. Tumors of the bladder and prostate with special reference to cancer. *Surg. Clin. North America*, 1929, *9*, 701–731.
4. Kretschmer, H. L. Carcinoma of the bladder with bone metastases. *Surg., Gynec. & Obst.*, 1922, *34*, 241–246.
5. Nicholls, M. F. A case of vesical papilloma with widespread metastases. *Brit. J. Surg.*, 1933, *21*, 108–112.
6. Wells, H. G. Bone metastasis from primary carcinoma of the urinary bladder. *J. Urol.*, 1922, *7*, 383–396.

# THE RELATION OF THE ENDOCRINE SYSTEM TO MALIGNANCY*

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THE student of human physiology cannot escape the impression that cellular growth in the human body is rigidly controlled. Babcock[2] calls attention to certain suggestive facts such as the regrowth of epithelium over a denuded area to the proper size without exuberance of tissue; the regrowth of the liver to proper proportions when part of it has been removed; the failure of skin, transplanted from one person's body to that of another, to grow, etc. There are undoubtedly forces in the body which stimulate and retard the growth of normal cells and since cancer seems to result from a derangement of these controlling factors, their study holds the greatest interest for the radiotherapist.

Much evidence has been accumulated indicating that the secretions from various internal organs play a vital rôle in both the formation of tumors and the retardation of their growth. Such structures as the spleen, thymus, thyroid and the adrenal tend to exert an inhibitory influence while the glands which control sexual activities, particularly the ovary, favor the development of certain malignant tumors.

The function of the spleen is poorly understood but pathologists are agreed that malignant metastases are rarely found in it. Williams[36] reported only two such implants in a series of 15,000 autopsies. Brancati[5] and Cimoroni[9] were unable to make transplants from malignant tumors grow in the spleens of animals, and Carra[8] reported an inhibitory influence exerted on transplants which were merely placed near the spleen. Oser and Pribram[29] went a step farther in that they carried out experiments which indicated that the susceptibility of animals to tumor transplants could be definitely increased by splenectomy.

The thymus has been thought to inhibit the growth of epithelial tumors for many years and the infrequency of epitheliomas in children is often accredited to the influence of this structure. Foulerton,[17] more than thirty years ago, attempted to treat carcinoma with injections of extracts made from the fresh thymus gland, and Gwyer[20] also thought the growth of certain malignant tumors could be retarded in this manner. Hanson[21] has more recently reported the softening of malignant neoplasms following the injection of karkinolysin which is a thymus gland product. On the experimental side Magnini[27] has demonstrated an acceleration of the growth of sarcoma after removal of the thymus in young animals, and Karnicki[23] states that thymectomy produces a fourfold increase in the rate of growth of tar cancer on the skin of animals.

Much that has been said about the thymus also applies to the thyroid. Rohdenburg, Bulloch and Johnston[31] in 1911 published evidence supporting their theory that thyroid secretion inhibited the growth of malignant tumors. More recently Karnicki,[23] working with experimental tar cancer in animals, has arrived at the same conclusion.

Everyone is familiar with the theory that a secretion from the adrenal gland is antagonistic to the growth of cancer because of the publicity given the Coffey and Humber[10] preparation. The effect of this extract, together with similar preparations made from the spleen and the ovary, on rat sarcoma was carefully studied by Bischoff and Maxwell.[4] They concluded that these materials brought about no regressions but in many instances they did produce a liquefaction and opening of the tumors. Many earlier workers such as

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Reicher[30] and Echtermeyer[16] believed that the local application and injection of adrenalin was a valuable therapeutic procedure, and Sokoloff[32] reported an actual regression of malignant tumors in rats after the injection of an extract of the suprarenal cortex in combination with certain iron salts.

Summarizing the foregoing material, it seems that certain glands in the human body do oppose the formation of malignant tumors. However, there is as yet no published evidence available indicating that the extracts of any of these organs will, when injected into the body, completely eradicate growing cancer cells.

The other side of the picture, namely, the formation of tumors through the activity of certain endocrine glands, is also of great interest. Most of the information now available centers about the female genitalia and it applies to benign as well as to malignant new growths. About five years ago Kakuschkin[22] advanced the theory that uterine fibroids were produced by the continued stimulation of the uterine wall by the follicular secretion in women who did not become pregnant. Witherspoon[38] has recently produced more evidence indicating that the unopposed action of estrin over a long period of time brings about the formation of fibromyomas. Reasoning in somewhat the same manner, Geschickter, Lewis and Hartman[19] have recently published the following statement regarding the female breast: "Gynecomastia, virginal hypertrophy and fibroadenoma are produced by the prolonged and uninterrupted stimulation of the duct epithelium and surrounding connective tissue of the breast by the hormone estrin."

Loeb[26] published data some fifteen years ago which clearly established the rôle of ovarian secretion in the formation of cancer of the breast in mice, and Cori[13] has more recently verified and augmented his findings. They worked with strains of animals, 56 to 80 per cent of which normally developed spontaneous mammary carcinoma. When castration was done before the animals were three months old no cancer developed. Castration done between the third and fourth months gave almost complete protection; between the fifth and seventh months partial protection, and after the seventh month no protection. The cessation of ovarian function produced no improvement if it was brought about after the tumor appeared.

Loeb tried unsuccessfully to produce cancer of the breast in male mice by long continued injections of folliculin. However, Lacassagne and Nyka[24] published an article in 1934 in which they stated that injections of benzoate of estrin dissolved in sesame oil given regularly from the time of birth into mice produced a rich network of excretory canals in the breasts of both sexes with the secretion of a substance like colostrum which condensed to form concretions. Cancer almost always appeared following this sequence of events. They also obtained folliculin from a cyst in a cancer of the breast of a woman fifty-seven years of age. Burrows[6] has recently noted the appearance of gynecomastia, cysts and growths resembling adenomas in the breasts of male mice following the prolonged external application of estrin dissolved in benzene. Two of his animals developed mammary cancer. This author[7] has also observed a hyperplasia and metaplasia in the prostates of these mice very similar to the changes observed in the hypertrophied prostates of elderly men. Zéphiroff and Dobrovolskaja-Zavadskaja[39] have obtained a fat-soluble hormone from adenocarcinomas of the breast in mice which resembles folliculin very closely.

Organic chemists have made their contribution to this subject by showing that the structural formulae of the carcinogenic elements in coal tar and the estrogenic elements in ovarian extracts are very similar. Cook, Hewett and Hieger,[11] after isolating a series of cancer producing substances from coal tar, concluded that the carcinogenic properties were possessed only by certain compounds formed from 1:2 benzanthracene which was itself inactive.

It was also demonstrated that the tricyclic phenanthrene ring system was common to the formulae of all the active hydrocarbons. Cook, Dodds, Hewett and Lawson[12] then tested the estrogenic properties of various coal tar products and were able to show that many of them had the power to induce estrus in castrated mice and rats. Their chemical studies indicated that the

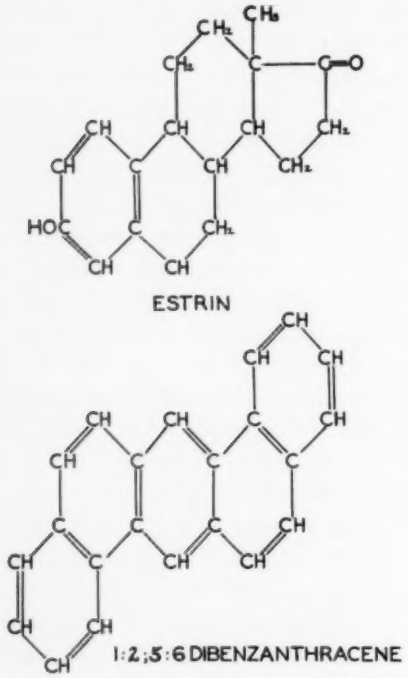


FIG. 1. 1:2; 5:6 dibenzanthracene, which is one of the strongly carcinogenic substances found in coal tar, has a structural formula somewhat similar to that of estrin. Both are formed by certain additions to a basic structure composed of three benzene rings.

estrogenic property was common to those derivatives of dibenzanthracene which had been hydrogenated and supplied with hydroxyl groups. Some substances had both estrogenic and carcinogenic properties but one was always much stronger than the other. The formulae for dibenzanthracene and estrin are shown in Figure 1. Their structures are somewhat similar, the chief difference lying in the presence of oxygen and a hydroxyl group in the estrogenic substance.

The foregoing data indicate that the presence of folliculin favors the formation of mammary cancer and it may even initiate the change in control which allows the epithelial cells in this region to become malignant. Burrows goes so far as to suggest that it may be possible in the future to estimate the likelihood of the development of cystic disease and cancer in the breasts of a given patient by the estimation of the output of estrogens and the rapidity of their disappearance from the blood stream. Loeb contends that malignant changes will occur only in those individuals who possess a hereditary cancer tendency. If we adopt these theories, how may our knowledge be utilized in clinical work?

Loeb's experiments indicate that castration offers little as a therapeutic procedure for carcinoma of the breast in mature individuals. However, Schinzinger suggested it in 1889 and Beatson[3] reported clinical improvement following surgical removal of the ovaries in 3 cases in 1896. Early in this century, Thomson[34] reported improvement in 22.5 per cent of 80 cases and Lett[25] in 26 per cent of 99 cases following castration. The surgical method did not gain much popularity but in 1909 Foveau de Courmelles[18] reported the first cases treated by radiation castration and was enthusiastic about his results. Later Wintz[37] adopted the procedure as a routine plan for his irradiated breast cases and was convinced of its value. The most scientific study of this problem has been carried out by Ahlbom[1] at the Radiumhemmet in Stockholm where he used radiation castration in the treatment of 163 unfavorable cases. Sixteen patients received no other form of therapy and it is his opinion that they obtained neither a prolongation of life nor any improvement in their tumors. In the remaining cases the addition of pelvic irradiation to the direct irradiation of the malignant tissue seemed to be of little benefit except in a small group of menstruating women past forty-five years of age. In spite of this report, Taylor[33] advocates castration as a routine procedure

for young women with mammary cancer, largely because of the likelihood of the appearance of cancer in the other breast during a subsequent pregnancy. His contention is partly based on a series of 29 patients less than forty years of age studied by Trout[35] after radical breast resections. Two later became pregnant and both of them developed cancer in the remaining breast. It is the author's opinion that routine castration with its subsequent train of undesirable symptoms is hardly justifiable in young women with mammary cancer, but the procedure can do no harm and may be of real value to women past forty years of age.

Although the foregoing statement applies to cancer of the breast and most of its visceral metastases it does not hold true for osseous metastases. Daland[14] in 1931 reported a case showing a marked improvement in the metastases to bone from a mammary carcinoma and I[28] reported a similar case in 1933. Dresser[15] has more recently described a series of 30 menstruating women with bone metastases treated with radiation castration. Seventy-three per cent of these patients experienced relief of pain and 30 per cent showed a definite regression of the secondary lesions evidenced by hyperplastic changes in the rarefied areas originally observed in roentgenograms of the affected bones. Little or no improvement occurred when the same treatment was administered to women past the menopause age. This procedure is so important that its value will be emphasized with a few case histories.

## CASE REPORTS

Case I. A married woman, aged thirty-four, had a radical resection of the left breast done for carcinoma in 1929. A subtotal hysterectomy without disturbance of the ovaries had been performed about six months previously. One and one-half years after the breast operation she was examined because of a marked loss of weight, indigestion and pain in her chest. Metastases were discovered in two thoracic vertebrae, several ribs, one clavicle and both scapulae.

In December, 1931, she was brought to Baylor Hospital in a semihysterical condition because she had been told that she had about two months to live. She lay in bed with her knees clasped firmly under her chin and seemed to be suffering much pain. She was taking large doses of morphine.

Areas over the front and back of the pelvis received 600 r (measured in air without back-scattering) on successive days using 200 kv., 6.0 ma., a target skin distance of 50 cm. and a filter of 0.75 mm. of copper and 1.0 mm. of aluminum. Single doses of the same type were given over the various bone lesions.

The morphine was gradually withdrawn so that it was completely discontinued at the end of three weeks. In six weeks she was almost free of pain and was able to sit up. Hot flashes were just beginning to appear. At the end of five months she was walking about and had gained 36 pounds. At seven months she had gained 42 pounds, and had no pain of any sort and was attending social functions in the evenings. Films made at this time showed definite recalcification of the metastatic areas.

At fourteen months local roentgen treatment was given to the thorax and lumbar region because of some pain in these areas. At sixteen months the skull was treated and completely epilated because the patient's attention had been unnecessarily focused on some small bone metastases in this region following roentgen examination in another clinic. At two years she developed pain in the left chest and a moderate amount of bloody fluid was aspirated from the pleural cavity. Roentgenograms revealed a band of soft tissue about 1½ inches wide at the periphery of the lower left chest. This lesion did not progress. At two years and eight months she developed rather severe pain in the lower lumbar region partially relieved by local roentgen therapy. At three years and two months from the time of castration she died with lung and liver metastases.

Case II. An unmarried woman, aged thirty-six, had a radical amputation of the left breast done for cancer in March, 1932. Five months later severe pain appeared in the region of the left hip and she was forced to stay in bed. In December, 1932, she was admitted to Baylor Hospital complaining of pain in the hip severe enough to require opiates. The thigh was held in a flexed position and the leg could not be straightened. Roentgen examination revealed

metastases in the neck of the right femur, right side of the pelvis and the acromium process of the right scapula.

and in four months she was getting about on crutches. At this time local recurrences on the chest wall and in the axilla were successfully

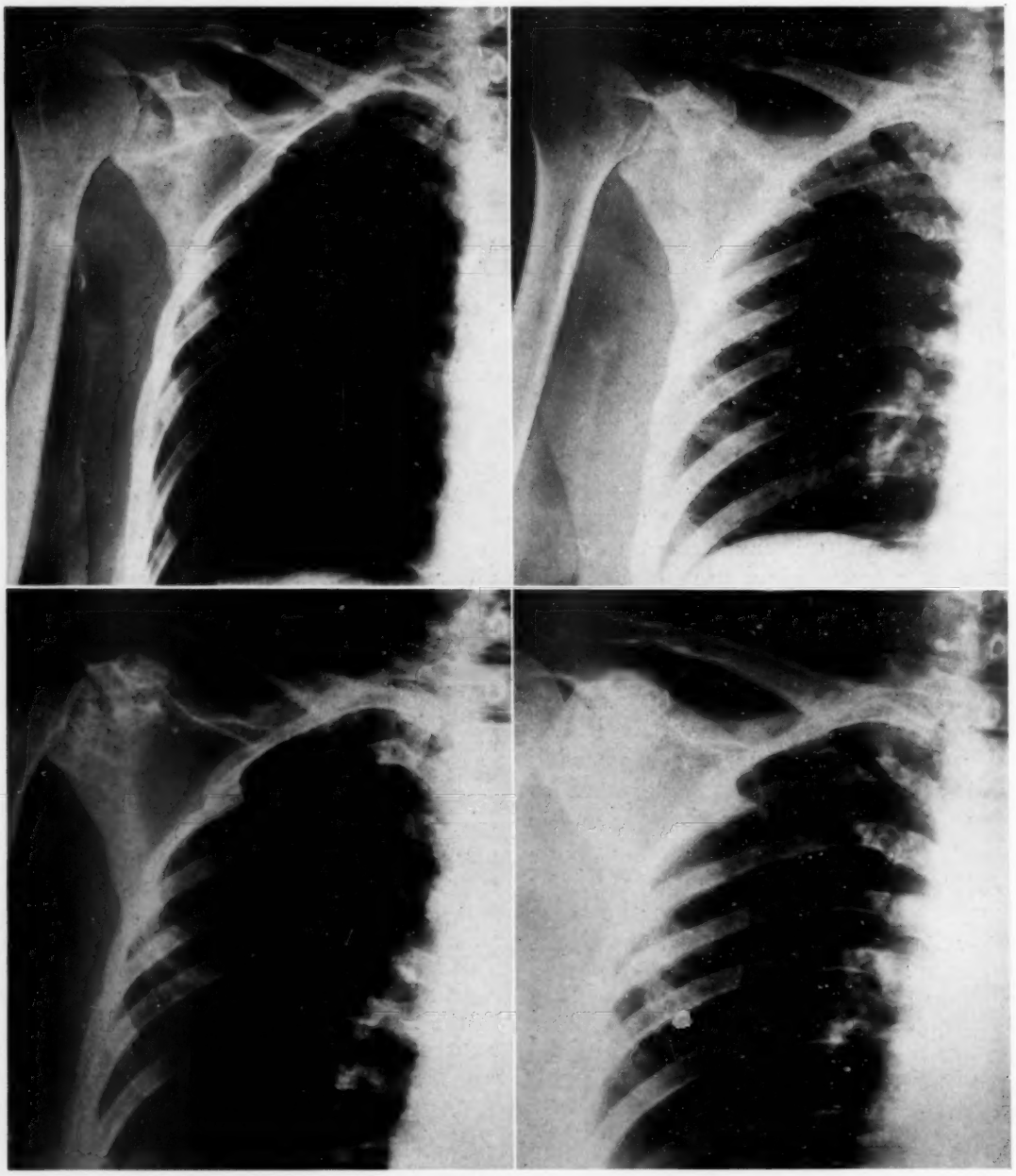

FIG. 2. Metastases to the right scapula and right clavicle from cancer of the breast in Case 1 as they appeared at the time of castration and three and a half months, two years and three years after castration.

Roentgen castration was immediately carried out as in the previous case and the bone lesions were also treated. In two weeks all the pain had disappeared and her medication was discontinued. In six weeks she was sitting up

treated with roentgen irradiation. At ten months the leg was straightened with the aid of an orthopedic consultant and she was then able to walk with a cane and to drive her car. She had gained a total of 22 pounds and films

of the pelvis showed a recalcification of the neck of the femur and multiple deposits of calcium in the bony pelvis, many of them being located in areas where no metastatic lesion had previously been discovered. She did well for two years, at the end of which time she went to another clinic because of digestive symptoms which she did not associate with her pervious trouble. She died in another city two years and four months after the castration was performed.

CASE III. An unmarried woman, aged forty-five, first consulted us in June, 1933, because of a tumor 1½ inches in diameter in the right breast. There were several small glands in the right axilla. She was not operated upon but twenty-three long weak radium needles of the type used by Keynes were buried under the tumor and in the axilla for seven days. The lymphatic areas received 600 r given in single doses. She had some pain in her back which was not seriously regarded at the time.

FIG. 3. Metastases to the left hip and pelvis from cancer of the breast in Case II as they appeared at the time of castration and two months, ten months and nineteen months after castration.

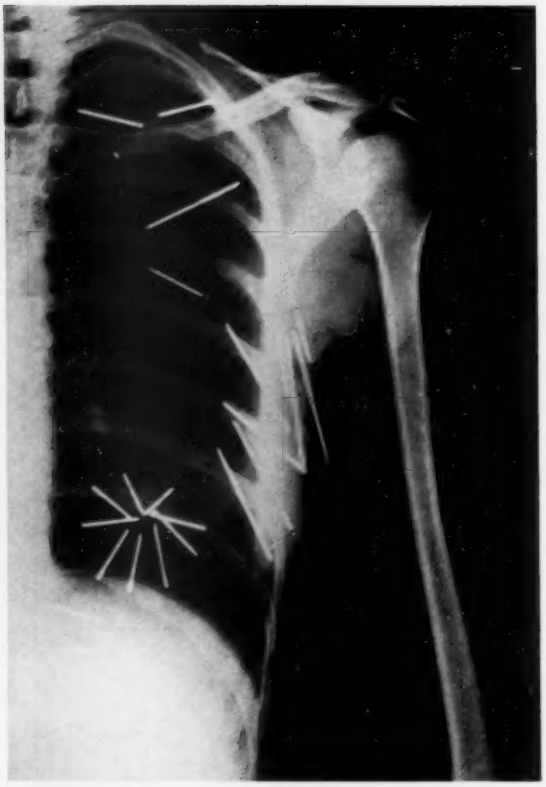

FIG. 4. Weak radium needle implantation done by the Keynes method for a cancer in lower right breast measuring 1½ inches in diameter in Case III. The tumor disappeared and has not recurred during two years of observation.

At the end of a month all evidence of the tumor had disappeared but she still had some back pain. At the end of four months films were made which showed a partial compression of the second lumbar vertebra. At that time the patient was confined to bed because of pain so severe that it required opiates for its relief. A roentgen castration was done immediately and the lesion was cross-fired with deep roentgen rays through two portals on the back, each of which received 600 r.

Six weeks after the treatment she was free of pain and able to sit up. At the end of three months the spine was again cross-fired with deep roentgen rays. She was then able to be up all the time and soon secured a position as a stenographer. She has worked regularly ever since, a period of two years and two months, and still has no pain and is in excellent general condition. Films made recently show no abnormality in the affected vertebra except some compression of one side.

The results obtained in these cases indicate that Dresser's conclusion that the improvement is due to the withdrawal of the ovarian hormone must be correct. In Case I, no local treatment was given for a period of fourteen months after castration and the calcification of the bone lesions was progressive during this entire period. The data available indicate that bone metastases from cancer of the breast should in most cases show a definite improvement following castration lasting from one to three years. In the author's cases the bone lesions showed little or no further activity but the patients eventually died with visceral metastases. Some explanation of the selective effect exerted on carcinoma grow-

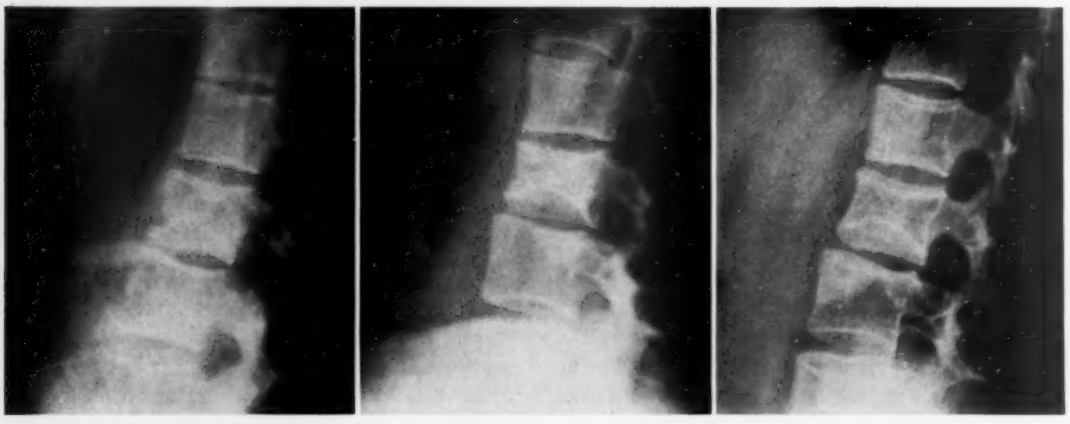

FIG. 5. Painful metastasis in second lumbar vertebra of Case III at the time that it was discovered and at periods of two months and two years after castration was done. The patient is still symptom-free.

ing in bone following the withdrawal of the ovarian hormone should be offered but the state of our knowledge of the endocrine system at the present time hardly justifies any intelligent attack on this problem. The excessive calcium deposits observed in the bones of Case II suggest that the parathyroid glands may play a rôle in the calcification of the malignant deposits but this conjecture is difficult of proof.

SUMMARY

1. The secretions from certain organs in the body, especially the spleen, thymus, thyroid and adrenal glands, seem to exert an antagonistic effect on the growth of malignant tumors.

2. The secretions from the ovary seem to favor the growth of benign tumors in the uterus and breast and malignant tumors in the breast.

3. No effective gland extracts for the eradication of cancer have as yet been prepared but the withdrawal of the ovarian hormone by castration produces marked benefit in certain advanced cases of cancer of the breast, especially those with bone metastases.

REFERENCES

1. AHLBOM, H. Castration by roentgen rays as an auxiliary treatment in the radiotherapy of cancer mammae at Radiumhemmet, Stockholm. *Acta radiol.*, 1930, *11*, 614–633.
2. BABCOCK, W. W. Organic control of growth and new growth. *Am. J. Surg.*, 1935, *28*, 67–70.
3. BEATSON, G. I. On the treatment of inoperable cases of carcinoma of the mamma. *Lancet*, 1896, *2*, 104–107; 162–165.
4. BISCHOFF, F., and MAXWELL, L. C. Hormones in cancer; effect of ovarian, splenic, and adrenal extracts upon rat sarcoma No. 10. *J. Pharmacol. & Exper. Therap.*, 1930, *40*, 97–113.
5. BRANCATI, R. Sul comportamento della milza negli animali con tumore. *Tumori*, 1912, *1*, 561–575.
6. BURROWS, H. Pathological changes induced in the mamma by oestrogenic compounds. *Brit. J. Surg.*, 1935, *23*, 191–213.
7. BURROWS, H. Pathological conditions induced by oestrogenic compounds in the coagulating gland and prostate of the mouse. *Am. J. Cancer*, 1935, *23*, 490–512.
8. CARRA, J. Cultures affrontées in vitro de tumeurs et d'organes à sécrétion interne. *Néoplasmes*, 1924, *3*, 5–17.
9. CIMORONI, A. Sulle modificazioni della milza e del fegato nei portatori di epitelioma. *Tumori*, 1912, *1*, 691–700.
10. COFFEY, W. B., and HUMBER, J. D. The effect of a suprarenal extract for malignant growth. *J. Am. M. Ass.*, 1930, *94*, 359.
11. COOK, J. W., HEWETT, C. L., and HIEGER, J. The isolation of a cancer producing hydrocarbon from coal tar, I, II and III. *J. Chem. Soc.*, Part I, 1933, 395.
12. COOK, J. W., DODDS, E. E., HEWETT, C. L., and LAWSON, W. The oestrogenic activity of some condensed-ring compounds in relation to their other biological activities. *Proc. Roy. Soc., London, Ser. B.*, 1934, *114*, 272–286.
13. CORI, C. F. The influence of ovariectomy on the spontaneous occurrence of mammary carcinomas in mice. *J. Exper. Med.*, 1927, *45*, 983–991.
14. DALAND, E. M. Cancer of the breast. *Am. J. Cancer*, 1931, *15*, 2361–2366.
15. DRESSER, R. The effect of ovarian irradiation on the bone metastases of cancer of the breast. AM. J. ROENTGENOL. & RAD. THERAPY. To be published.
16. ECHTERMEYER. Inoperable Carcinom des Zungengrundes durch Adrenalininjektionen gebessert. *Berl. klin. Wchnschr.*, 1911, *48*, 1566.
17. FOULERTON, A. G. R. A note on treatment of carcinoma with injection of fresh extract of thymus and thyroid glands. *Arch. Middlesex Hosp.*, 1904, *2*, 143–149.
18. FOVEAU DE COURMELLES. Nouveau traitements physicothérapiques du cancer. *Rev. méd.*, 1910, *20*, 91–95.
19. GESCHICKTER, C. F., LEWIS, D., and HARTMAN, C. G. Tumors of the breast related to the oestrin hormone. *Am. J. Cancer*, 1934, *21*, 828–859.
20. GWYER, F. Thymus gland treatment of cancer. *Am. Surg.*, 1907, *46*, 86–94.
21. HANSON, A. M. Report of four cases of inoperable carcinoma treated with intramuscular injections of karkinolysin. *Minnesota Med.*, 1930, *13*, 65–73.
22. KAKUSCHKIN, N. The etiology and prophylaxis of myoma of the uterus. *Zentralbl. f. Gynäk.*, 1930, *54*, 2899–2909.
23. KARNICKI, W. On the influence of endocrine glands upon the development and condition of experimental cancer. *Ztschr. f. Krebsforsch.*, 1932, *35*, 523–542.

24. LACASSAGNE, A., and NYKA, W. Regarding the pathogenesis of mammary adenocarcinoma. *Compt. rend. Soc. de biol.*, 1934, *116*, 844–845.
25. LETT, A. An analysis of 99 cases of inoperable carcinoma of the breast treated by oöphorectomy. *Lancet*, 1905, *1*, 227–228.
26. LOEB, L. Further investigations on the origin of tumors in mice. VI. Internal secretion as a factor in the origin of tumors. *J. Med. Research*, 1919, *40*, 477–496.
27. MAGNINI, M. Sulla evoluzione degli innesti neoplastici nei ratti timectomizzatti. *Tumori*, 1912, *2*, 325–335.
28. MARTIN, C. L. New developments in irradiation therapy of breast cancer. *Texas State J. Med.*, 1933, *29*, 186–191.
29. OSER, E., and PRIBRAM, E. E. Ueber die Bedeutung der Milz in dem an malignem Tumor erkrankten Organismus und die Beeinflussung von Tumoren durch Milzbrei. *Ztschr. f. exper. Path. u. Therap.*, 1912–1913, *12*, 295–302.
30. REICHER, K. Experimentelle Beiträge zur Therapie maligner Tumoren. *Deutsche med. Wchnschr.*, 1910, *36*, 1356–1359.
31. ROHDENBURG, G. L., BULLOCH, F. D., and JOHNSTON, P. J. The effects of certain internal secretions on malignant tumors. *Arch. Int. Med.*, 1911, *7*, 491–499.
32. SOKOLOFF, B. Liquefaction of malignant tumors and iron metabolism. *Am. J. Physiol.*, 1929, *90*, 521–522.
33. TAYLOR, G. W. Artificial menopause in carcinoma of the breast. *New England J. Med.*, 1934, *211*, 1138–1140.
34. THOMSON, A. Analysis of cases in which oöphorectomy was performed for inoperable carcinoma of the breast. *Brit. M. J.*, 1902, *2*, 1538–1541.
35. TROUT, H. H. The remaining breast after radical removal of the opposite side for carcinoma. *Surg., Gynec. & Obst.*, 1922, *24*, 630–632.
36. WILLIAMS, W. R. The Natural History of Cancer, with Special Reference to its Causation and Prevention. W. Heineman, London, 1908.
37. WINTZ, H. Die Röntgenbehandlung des Mammakarzinoms. Georg Thieme, Leipzig, 1924.
38. WITHERSPOON, J. T. Interrelationship between ovarian follicle cysts, hyperplasia of the endometrium and fibromyomata. *Surg., Gynec. & Obst.*, 1933, *56*, 1026–1035.
39. ZÉPHIROFF, P., and DOBROVOLSKAJA-ZAVADSKAJA, N. On a fat soluble estrogenous substance isolated from spontaneous mammary tumors of mice. *Compt. rend. Acad. d. sc.*, 1934, *199*, 589–591

## DISCUSSION

DR. RICHARD DRESSER, Boston. Dr.Martin has given a most able discussion of a subject which has interested me for several years.

(Slide) Seven years ago, a woman, aged thirty-three, was referred for irradiation of recurrent and metastatic cancer of the breast, two years postoperative. She had extensive disease through the bones of the pelvis and the spine and also a diffuse metastatic process which you see here in the bones of the skull. In order to relieve her pain, we gave her a very moderate dose of high voltage roentgen radiation to the lumbar spine and pelvis. Strangely enough not only was her pain relieved, but the metastatic process regressed in the area irradiated, and also the bones of the skull returned practically to normal, although there had been no irradiation directed to the skull itself. Incidentally, there was a cessation of menstruation following the irradiation.

A year later, a similar case was referred to the Massachusetts State Cancer Hospital for terminal care. The patient was forty years old. Her breast had been amputated for cancer two years before. A month before, Dr. Sosman had examined her and found extensive bone and lung metastases. She was having extreme pain in the back and lower extremities. We gave her moderate irradiation to the spine and pelvis, hoping we might relieve this pain, and again to our surprise the metastatic process regressed not only in the area irradiated but other areas. You see the skull has returned practically to normal.

We concluded from these two cases that our results must be due to the cessation of ovarian function which was produced by the irradiation to the pelvis, so that we have continued with a series of cases of cancer of the breast showing bone metastasis.

(Slide) Total number of cases irradiated, 59. We have taken two groups; first, cases that have not passed the menopause, under forty-five (30), and a group of 29 for comparison that have passed the menopause.

(Slide) Taking the second group, those cases over forty-five years of age, there has been regression of bone metastasis in not a single case. I might say this regression is determined by frequent roentgen examinations. Forty-eight per cent were relieved of pain more or less temporarily, and in approximately half

the cases there was no result whatsoever from the irradiation.

In the next group, those that have not passed the menopause, we find very definite regression of metastases as determined by follow-up roentgen examinations in 9, or 30 per cent. We got relief of pain without demonstrable regression of the metastatic process in 43 per cent, and approximately one-quarter of the cases were not at all affected by irradiation.

Encouraged by the results obtained in these advanced cases, we are now applying roentgen castration (high voltage radiation over the pelvis) in all cases of cancer of the breast in young women, both the advanced cases and the favorable cases.

In the more favorable group, the patient reports, is found operable and the breast is removed by radical operation. Ten days after the operation, we give postoperative irradiation to the operated site and then follow it by a sterilizing dose of roentgen rays to the pelvis.

We have not a sufficient number of these more favorable cases, and we have not followed them long enough to give any definite report as yet, but we feel that the method certainly does offer something if only in a palliative way.

Dr. George E. Pfahler, Philadelphia. I am convinced that in the woman who is still menstruating and has carcinoma of the breast, she had better be sterilized by irradiation, but that will not cure all of the lesions, as Dr. Dresser has shown.

Within the past six months, I have had an experience with a recurrent carcinoma and extensive metastasis in a young woman whom I have had under observation and treatment off and on for six years on account of metastasis. This last summer, she developed extensive disease of the pelvis. She had had disease of the 12th dorsal vertebra previously, but on account of the disease of the pelvis I then sterilized her completely and also treated the 12th dorsal but she had also extensive metastases in the ribs and the lungs. I saw her two weeks ago and reëxamined her. The lesions in the pelvis and the spine have shown decided improvement but the lesions in the chest and ribs have shown no improvement whatever, showing, I believe, we should not only treat the ovaries but also the whole lesions.

Dr. Milton Friedman, Newark, N. J. As we are demonstrating in our exhibit downstairs, our results seem to differ with the general conclusion that estrin is the exclusive stimulant to benign hyperplasias of the breast. Approximately 50 per cent of the cases fall into that group. In the other 50 per cent of benign hyperplasias of the breast, there seems to be a deficiency of estrin, because the administration of estrin causes a disappearance of hyperplasia. In the study of patients with carcinoma of the breast we do not find excessive estrin in the urine or blood. There seems to be more than the one simple factor of an excessive amount of estrin aggravating the neoplasms.

Dr. Goldfeder, at Bellevue Hospital, has been able to grow, in culture, tissue from a metastatic node of a breast carcinoma fairly easily but has been unable so far to culture any of the tissue taken from the breast itself. This would seem to indicate the presence of a still unknown local growth retarding chemical or mechanism which has no connection with sex hormones.

Dr. Martin (closing). The last speaker's remarks indicate that he is quite familiar with endocrinology, and I was much interested in what he had to say.

Routine castration in patients with cancer of the breast may be a helpful procedure, but the ill effects that so frequently appear when it is carried out in young women have prevented my adopting it except when bone metastases are present. Dr. Pfahler has described the good results obtained from the direct application of roentgen rays to the involved bones, and I believe, as he does, that this technique should always be used. However, I am convinced that castration improves the results obtained and makes them last longer and I see no objection to its use.

# RADIATION THERAPY OF INOPERABLE INTRA-ABDOMINAL MALIGNANCY

## WITH SPECIAL REFERENCE TO THE STOMACH*

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### HISTORICAL

SPORADIC attempts have been made to treat inoperable gastric cancer since 1903 when Lemoine and Doumer[9] reported 3 cases materially benefited by roentgen therapy. Delherm and Beau[3] in a study of statistics previously made public by Werner (205 cases), Finsterer (19 cases), von Bombard (21 cases), Stark (8 cases), and a review of the results obtained by Jüngling, Scholander and Tengwall,[12] Solomon, and Holfelder[6] reveal outstanding instances of palliation but no survival of note except Werner's patient who survived three and a half years and 2 of Holfelder's, who were living and well two and a half and three and a half years respectively when reported. Holfelder[6] asserts that "scirrhous carcinoma of the stomach with diffuse thickening of the stomach walls is not benefited by irradiation but gastric carcinoma in which a tumor is found is usually radiosensitive regardless of its intra-gastric location."

Scholz[13] employed roentgen irradiation over a barium-filled stomach plus a gastroenterostomy and reports a seven year cure in a gastric tumor mass. Kaplan[7] makes a detailed report of 108 gastric carcinomas and concludes that early diagnosis and a radical operative procedure are essential to reduction of death rate. He states that irradiation has thus far been of little avail in his hands. Friedmann,[4] in 1934, reported a gastric carcinoma treated by him in 1927 after a partial gastrectomy. This patient lived four years in perfect health and died in the fifth year of liver metastasis.

In all of these cases, the treatment given was probably inadequate compared with present-day standards.

### STATISTICS

Levin[10] presents a comprehensive analytical study of the most recent surgical statistics and concludes that "radical surgery to date does not solve the problem of gastric cancer." He advocates radon interstitially and a "course of high voltage roentgen therapy over the abdomen."

The published statistics from the Cleveland Clinic by Crile[2] show that but 7 out of 736 cases of gastric malignancy survived the five year period, which is probably less than the normal survival rate had the disease been permitted to run its natural course. Knowledge common to all experienced physicians banishes the hope of curing the disease by surgical measures alone, save in the exceptional case.

No other noteworthy statistics are available on the roentgen treatment of gastric malignancy, probably because radiologists are timid about reporting their experiences when cytologic proof is lacking. This leads me to the declaration that the diagnosis of gastric malignancy can be made with a higher degree of accuracy by the roentgen examination than by any and all other methods not excepting exploration and the microscopic section.

There is one fundamental problem that cannot be estimated by a careful roentgenologic study and that is the sensitivity of the malignant stomach to irradiation. This, however, is readily determined by subjecting the patient to radiation therapy. Now that the fractional method of Coutard or its modification is coming into general use, we may determine within a period of two or three weeks at most the degree of tumor sensitivity, which statement applies to malignant new growths of

* Read at the Thirty-sixth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 24–27, 1935.
† From the Radiologic Clinic of Drs. Groover, Christie and Merritt.

the stomach as well as other suspected intra-abdominal malignant tumors.

We have advocated preoperative irradiation of obscure abdominal tumors for some years and have never observed that it delayed or prevented recovery. On the other hand, we have indubitable proof of its very great value as a life saving measure.

## DIAGNOSIS

An early diagnosis is obviously all-important. If the lesion is resectable we would not at this time advocate irradiation. However, it must be admitted that the cure of resectable lesions by surgery is the exception rather than the rule.

In the matter of routine procedure the roentgenologic method is far superior to any other. Kirklin[8] feels that "the roentgen-ray examination is the surest way of recognizing early malignant lesions of the stomach" and while he is not always able to differentiate a malignant from a benign ulcer he has followed many cases where the symptoms and clinical findings indicated a benign ulcer and found that the roentgenologic examination indicating malignancy was correct.

Moore[11] states that "the roentgenologic diagnosis of gastric carcinoma is a highly accurate procedure—in experienced hands the percentage of error should be less than 5 per cent, the chief source of error being the failure to recognize small, non-obstructive lesions in the cardiac portion of the stomach. Certain lesions may simulate malignancy, such as lues and benign growths, while foreign material in the gastric lumen and deformities from extrinsic pressure, especially gas in the colon, have been mistaken for cancer of the stomach. However, the trained roentgenologist rarely is deceived by these. The roentgenologic differentiation between a simple ulcer and an ulcerating carcinoma is extremely precise. Since the percentage of error is practically entirely on the negative side a positive roentgenologic diagnosis of gastric malignancy must justify the treatment indicated for the individual patient and the results obtained be accepted as authentic."

Gray, Balfour and Kirklin[5] in their monograph on cancer of the stomach state that, "Today chief reliance is placed on roentgen rays for the discovery of carcinoma, especially in its early stages and in *most* cases a confident diagnosis can be made without consideration of the clinical history. In addition, the roentgenologic method will determine the situation, extent and probably histologic character of the new growth." Concluding, they declare, "When the roentgenologic examination reveals gastric disease the nature of which is doubtful, the diagnosis should always include carcinoma as a possible alternative, for approximately 75% of the gastric lesions exposed on the operating table are malignant."

Finally, I have a communication from Dr. Lewis Gregory Cole[1] in which he very graciously permits me to quote him in the matter of diagnosis as follows: "Roentgenological diagnosis of gastric neoplasms and their differentiation from inflammatory lesions is more accurate than pathological diagnosis and differentiation based on microscopic sections. This radical statement is made with due consideration for established facts. An analysis of pathological findings reveals an incomprehensible diversion of opinion among reputable pathologists as to whether the lesions were malignant or non-malignant and still further dissension as to the type of lesion. I hope to be present at the meeting to exhibit both the roentgenological and pathological findings in these cases at the scientific exhibit."

## CASE REPORTS

This communication consists of a preliminary report on a series of 13 cases treated since January 1, 1934. Three are living and apparently well and free of all evidence of disease, roentgenologic examinations of their stomachs having been made within the past month. One is living with roentgenologic evidence of disease. Nine are dead of the disease.

We have taken these cases for treatment without regard to the condition of the pa-

TABLE I

ROENTGEN THERAPY IN GASTRIC MALIGNANCY

| Sex | Age | Location | Life after Treatment | No. Treatments | Tumor Dose |
|---|---|---|---|---|---|
| | | | DEAD | | |
| F | 53 | Body | 1 day | 7 | |
| M | 79 | Linitis plastica | 1 month | 4 | |
| M | 69 | Fundus (postoperative) | 4 months | 24 | |
| F | 42 | Body | 3 months | 20 | |
| M | 56 | Pylorus | 2 months | 12 | |
| M | 60 | Entire stomach | 2 months | 26 | |
| M | 46 | Pylorus (postoperative) | 1 month | 22 | |
| M | 52 | Entire stomach | 2 months | 23 | |
| M | 59 | Esophagus and fundus | 5 months | 33 | 3,200 r |
| | | | ALIVE | | |
| M | 57 | Esophagus and fundus | 3 months recurrence | 24 | 2,100 r |
| M | 50 | Fundus and body | 1 year 8 months | 23 | 2,200 r |
| F | 48 | Body | 1 year 5 months | 24 | 2,500 r |
| M | 72 | Fundus and body | 7 months recurrence | 24 | 1,700 r |
| | | | 7 months well | 38 | 4,100 r |

FIG. 1. Case 1. Lymphosarcoma of the stomach, showing deformity on lesser curvature before roentgen therapy.

tient or the extent of the involvement of the stomach and most of those who succumbed were in a dying condition when treated. This statement also applies to one of the three who is living and well today.

We have learned, much to our surprise, that subjects suffering from malignant disease of the stomach tolerate treatments very well. Treatments are given daily, except Sunday, after the modified Coutard technique. We are indebted to Dr. Vincent W. Archer of Charlottesville, Virginia, for the privilege of reporting an additional case of malignant disease of the stomach treated by him in 1931.

CASE 1. P. D. White female, aged fifty-one. Treated by Dr. Vincent W. Archer. Admitted to University of Virginia Hospital in May, 1931, complaining of epigastric pain after meals of one year duration. There was some nausea and vomiting and a great loss of strength. In two years the patient had lost 71 pounds in weight. Roentgen examination of the stomach showed a persistent deformity on the lesser curvature (Fig. 1). An exploratory laparotomy was done and multiple nodular and ulcerated areas were found within the stomach. Resection was impossible so a posterior gastro-

enterostomy was done. Biopsy showed lymphosarcoma. Wassermann reaction was negative. From May 28, 1931, to June 13, 1931, the patient received two erythema doses of deep roentgen therapy to each 20×20 cm. area over the anterior and posterior stomach. In September, 1931, the patient was again treated for a mass in the epigastric area. The patient has remained well four and one-half years since treatment. Figure 2 shows the condition of the stomach at the present time.

FIG. 2. Case I. Showing present condition of the stomach four and one-half years after roentgen therapy.

CASE II. M. C. White female, aged forty-eight. For three months the patient complained of epigastric pain and mucous stools (never tarry nor bloody). On palpation there was a very hard lemon-size mass in the epigastrium. Roentgen examination showed the palpable mass to be on the lesser curvature of the stomach (Fig. 3). Wassermann reaction was negative. From April 19, 1934, to May 18, 1934, the patient received 2,500 r (measured in air) to an area 20×20 cm. over the anterior stomach and 2,300 r to an area 20×20 cm. over the posterior stomach with the following factors: 220 kv. (peak), 20 ma., 50 cm. distance, Thoraeus tin filter equivalent to 2 mm. copper, half-value layer 2 mm. copper. The first treat-

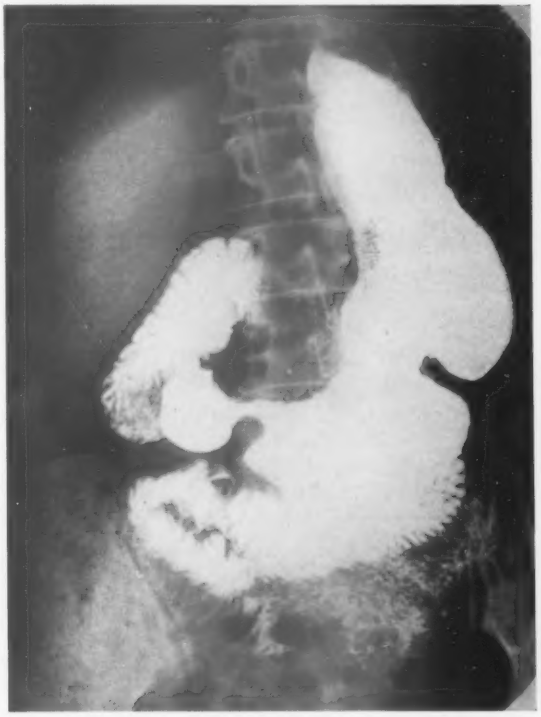

FIG. 3. Case II. Showing deformity on lesser curvature corresponding to lemon-sized palpable mass.

FIG. 4. Case II. Showing normal stomach one year and five months after roentgen therapy.

FIG. 5. Case III. Showing extensive papillary carcinoma Grade 1 before roentgen therapy.

ment was 100 r, the subsequent treatments were rapidly lengthened until the patient was receiving 250 r daily to a single area. The daily dose was kept at 250 r thereafter, and the two areas were treated on alternate days. The patient was only slightly nauseated by the treatment. Her general condition was much improved at the end of the treatment. The abdominal mass disappeared. The skin showed only a dry exfoliation two weeks after concluding treatment. In five months the patient gained 16 pounds. Patient has remained well one year and five months and is on a full diet. Figure 4 shows stomach at present time.

CASE III. I. C. White male, aged seventy-two. Eight years previous to examination the patient fell off a horse and struck his side. He dates the onset of his trouble from that time. For the past seven months he has had indigestion. No nausea or vomiting. Figure 5 shows extensive papillary carcinoma involving almost the entire body of the stomach. Wassermann was negative. From June 18, 1934, to July 14, 1934, the patient received 2,100 r to an area 20×20 cm. over the anterior stomach, 2,100 r to an area 20×20 cm. over the posterior stomach and 600 r to an area 20×20 cm. over the lateral stomach with the following factors: 220 kv. (peak), 20 ma., 50 cm. distance, Thoraeus tin filter equivalent to 2 mm. copper. The tumor dose was 1,700 r. The initial treatments were 100 r; these were lengthened after a few days until each area was receiving 250 r in rotation, only a single area being treated daily. Patient was not nauseated nor did he vomit at any time during or after treatment. Roentgen examination of the stomach two months after treatment showed considerable improvement. There was still, however, evidence of malignancy on the posterior wall. There was a dry desquamation of the skin. The stomach was washed and the centrifuged material was studied by Dr. J. W. Lindsay who reported papillary carcinoma on several fragments. In spite of the previous intensive therapy it was decided to give the patient a second series of roentgen therapy, more intensive than the first. To save the skin and improve the depth

FIG. 6. Case III. Showing epidermitis two weeks after patient received 3,000 r to each of three areas over the stomach, anterior, lateral and posterior.

dose a tin filter equivalent to 5 mm. copper was used. Six months after the first series the patient received 3,000 r (measured in air) to each of three 20×20 cm. areas, or a total of 9,000 r in forty-two days with the following factors: 220 kv. (peak), 20 ma., 50 cm. distance, 250 r daily, 25 minutes, with 1.25 mm. tin, 0.25 mm. copper and 1 mm. aluminum filtration. The tumor dose was 4,100 r. The patient tolerated the second series of treatment without nausea or vomiting and lost no weight. Figure 6 shows the skin reaction at its height two weeks after treatment. This healed without difficulty in four weeks. The patient is symptom-free now for one year and four months since the first treatment and seven months since the second series of treatment. Figure 7 shows the stomach at the present time.

Case iv. H. W. White male, aged fifty. Complained of epigastric pain following meals of three months' duration. Vomited blood on several occasions and stools showed occult blood. Lost 6 pounds in weight and appeared very ill and cachectic. Wassermann reaction was negative. Roentgen examination of the stomach showed an extensive ulcerating carcinoma on the posterior stomach wall (Fig. 8). From January 10, 1934, to February 3, 1934, the patient received 2,150 r to the posterior stomach, over a 20×20 cm. area, and 2,350 r to the anterior stomach. The tumor dose was 2,200 r. The following factors were used: 220 kv. (peak), 20 ma., 50 cm. distance, Thoraeus tin filter equivalent to 2 mm. copper. There was immediate improvement in the patient's condition after the first treatment of 100 r. After a few days he was receiving 250 r daily to a single area, the two areas being treated alternately. The skin blistered two weeks after treatment and was healed in three weeks. The patient's weight was 108 pounds at conclusion of treatment; after five months it was 141 pounds, and nine months after treatment it was 169 pounds. The patient has remained symptom-free now for one year and eight months. Figure 9 shows the stomach at the present time.*

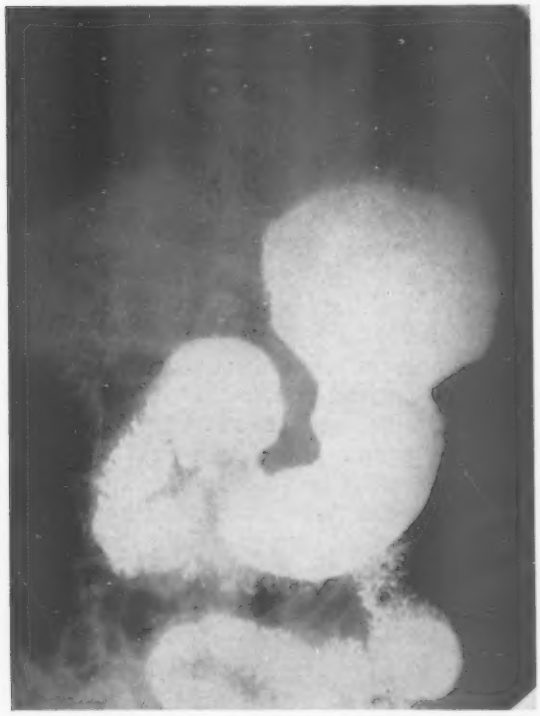

Fig. 7. Case iii. Showing normal stomach one year and four months after initial roentgen therapy.

Fig. 8. Case iv. Showing ulcerating malignancy on posterior wall of stomach before roentgen therapy.

* Cases i, ii and iv are alive and well in September, 1936. Case iii died twenty-one months after treatment. Six additional cases have been treated with good palliation in 5 cases, but all 6 are now dead.

FIG. 9. Case IV. Showing normal stomach one year and eight months after roentgen therapy.


REFERENCES

1. COLE, LEWIS G. Personal communication.
2. CRILE, G. End-results of the treatment of malignant disease at the Cleveland Clinic. *Surg., Gynec. & Obst.*, 1933, *56*, 417. Abs. in AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *34*, 141.
3. DELHERM, L., and BEAU, H. Que faut-il attendre du traitement radiothérapique des tumeurs de l'estomac. *Paris méd.*, 1930, *1*, 190–192.
4. FRIEDMANN, J. Carcinoma of the stomach; report of a case treated by roentgen therapy. *Radiology*, 1934, *23*, 104–107.
5. GRAY, H. K., BALFOUR, D. C., and KIRKLIN, B. R. Cancer of the stomach. *Am. J. Cancer*, 1934, *22*, 249–286.
6. HOLFELDER, H. Fortschritte der Röntgentherapie der Krebse des Verdauungskanals. *Strahlentherapie*, 1931, *43*, 497–503.
7. KAPLAN, I. I. A report of over 1,000 unselected cancer cases, treated in 1931–1932, at the New York City Cancer Institute, Welfare Island. *Radiology*, 1933, *20*, 433–449.
8. KIRKLIN, B. R. Personal communication.
9. LEMOINE and DOUMER. Traitement d'un cas de cancer de l'estomac par les rayons X. *Bull. Acad. de méd.*, 1903, *49*, 719–721.
10. LEVIN, I. Intraperitoneal insertion of radon and gastroenterostomy in carcinoma of the pyloric end of the stomach. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *34*, 69–76.
11. MOORE, A. B. Personal communication.
12. SCHOLANDER, A., and TENGWALL, E. Ein Fall von röntgenbehandeltem inoperablem Cancer ventriculi mit langdauernder Besserung. *Acta radiol.*, 1926, *7*, 415–418.
13. SCHOLZ, T. Application of roentgen radiation to the barium-filled stomach; contribution to the radiation treatment of inoperable gastric tumors. *Radiology*, 1932, *18*, 269–276.


DISCUSSION

DR. CHARLES A. WATERS, Baltimore, Md. I was delighted to be asked to open the discussion on Dr. Merritt's paper, chiefly because he is the first to come out in recent years and openly advocate irradiating these abdominal cancers. It is also gratifying to note the conservative though positive position he takes in this problem. While his statistics are yet small, they are large enough to signify that things can be accomplished now that were unheard of years ago.

His 3 cases living and well, and apparently free of disease would indicate that in his series of 13 cases about 23 per cent were materially helped. They were probably cases which might not have survived the hospital mortality and were probably in the inoperable group.

Why have our results in the treatment of cancer of the gastrointestinal tract been so unsatisfactory? Probably due to two things: (1) the lack of knowledge concerning radiosensitivity of tumors, and (2) the improvement in the method of application of radiant energy.

I am sure we are all still of the opinion that radical resection in cancer is still the method of choice, but there are many cases in which nothing is ever done and the patient sent home without any palliative treatment being tried. Dr. Merritt, ourselves and others have already found and reported instances when inoperable abdominal tumors have been rendered operable, but let us examine our records.

I will show a series of slides covering the statistics from the Mayo Clinic, the Johns Hopkins Hospital and the Union Memorial Hospital in Baltimore. These statistics are those of Balfour, Rankin, Whipple and Raiford, Pack, McLanahan, Merritt, Ewing, Martzloff, Healy, Broders and others.

An analysis of these various statistics indicates that approximately 50 per cent of all carcinomas of the gastrointestinal tract are inoperable with an operative mortality of 21

per cent. The resectable ones without distant involvement yielded approximately 23 per cent of five year cures.

Whipple and Raiford found that approximately 38 per cent of gastric cancers fell into Grade III and 44.2 per cent into Grade IV. Going still further it was found, from various statistics, that of all gastrointestinal cancers about 31 per cent belong in Grade III and 22 per cent in Grade IV. Therefore, it is reasonable to suppose that many of the cancers of the stomach, colon and rectum are radiosensitive to a greater or lesser degree than was generally supposed. If this be true one is forced to the conclusion that radiotherapy is destined to play an increasingly prominent rôle in this problem.

Pack states that the majority of cancers of the stomach are radioresistant, only about 10 per cent in his series showing clinical improvement after irradiation. This may be explained by the fact that he refers only to the inoperable gastric tumors treated in his series by this means. If this is true it is possible that a large percentage of his gastric cancers may have been Grades I, II and low III.

Ewing has recorded a small cell type of cancer originating in the base of the gastric glands, some of which are anaplastic resembling lymphosarcoma in their structure and are radiosensitive. All of which definitely indicates a trend that many gastric cancers are influenced to varying degrees by irradiation.

I should like to record a case of gastric tumor which proved on exploration to be entirely inoperable. However, it was highly radiosensitive and almost completely disappeared under irradiation. It subsequently proved to be a Grade III adenocarcinoma. The second operation revealed only a small nodule in the pylorus which was resected by a Pólya closure. The patient subsequently died an acute abdominal death and generalized abdominal metastasis was discovered. This case, however, proved one thing if nothing more and that is that a stomach which was completely involved by an unusual rubbery type of growth responded to irradiation and became entirely operable. The character of deeply seated abdominal malignant disease is often such as to defy every known method of scientific investigation. The time honored surgical exploration of the abdomen as the primary step in the treatment of abdominal masses of uncertain etiology and uncertain operability may, we believe, be obviated in some cases by preoperative irradiation.

At one time there was relatively little hope for success in the treatment of carcinoma of the cervix of the uterus. Irradiation today has gone a long way toward dispelling this hopelessness and probably there would be no basis for the hope of similarly brilliant results in the domain of gastrointestinal irradiation, but certainly here is fertile field which may yield the unexpected.

DR. ARTHUR U. DESJARDINS, Rochester, Minn. I am delighted that Dr. Merritt has brought up this very interesting and important question, not only for the members of this Society but for the profession as a whole.

It seems to me a mistake to use the general word "malignancy" when we refer to a specific variety, such as carcinoma. Carcinoma is a variety of malignancy, but there are several others. In writing papers and talking about malignant conditions, we should be more careful and more explicit, so as to avoid confusion.

The best pathologists in the world often have difficulty in distinguishing between a malignant epithelial cell tumor and a tumor of lymphoid origin, and they freely and frankly admit it. Not infrequently, when we receive a pathologic report of carcinoma, grade 4, or even some of grade 3, the condition subsequently proves to be lymphosarcoma or Hodgkin's disease. Another thing: the percentage of cases in which lymphoblastoma begins in the abdomen, that is, in which the main portion of the pathologic process is in the abdomen, is much greater than is generally realized. We have had an opportunity to treat a number of patients who had what was regarded as inoperable cancer of the stomach, and the percentage of substantial improvement among them has been about 20. By this I mean improvement sufficient to make the treatment worth while, considerable improvement in the general as well as the local condition. So far we have not been able to obtain cure or anything more than temporary improvement, probably because we have not been as thorough in our treatment as Dr. Merritt.

# THE TREATMENT OF CANCER OF THE SKIN BY DIVIDED DOSES OF HIGH VOLTAGE ROENTGEN RAYS*

*By* RICHARD DRESSER, M.D., *and* CHARLES E. DUMAS, M.D.
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THE voluminous literature which has accumulated on the treatment of cancer of the skin attests the interest that radiologists have shown in the management of this condition. Approximately 95 per cent of small superficial epitheliomas can be cured by adequate doses of radium or roentgen rays, or by surgery. The cosmetic results following irradiation are usually much better than those obtained by operation. Since a larger percentage of epitheliomas are located on the face, irradiation is preferable to surgery.

It has been our practice for many years to treat small cancers of the skin with single intensive doses of lightly filtered roentgen rays or radium (5 to 10 skin erythema doses). The third degree reaction thus produced, if limited to a small area, will heal readily, there will be little scar formation, and a high percentage of cures will result.

When the area involved by the epithelioma is large, and particularly when the lesion is indurated, the problem becomes more difficult. A single intensive dose of radium or roentgen rays sufficient to cure the lesion will often result in a radiation necrosis which will heal very slowly, or perhaps not at all. It has been our experience that treatment of lesions 1 centimeter or more in thickness with long wave roentgen rays of little penetrating power or the beta rays of radium often results in primary healing, but with a high percentage of recurrences, presumably due to the fact that the base of the epithelioma has received too little radiation.

The implantation of platinum needles of low radium content (2–3 mg.) has proved satisfactory in the treatment of large epitheliomas, but many radiotherapists do not have this type of equipment available. Moreover, the even distribution of radium needles throughout a large neoplasm is a difficult technical procedure and, if not properly carried out, will leave under-irradiated areas between the needles which are sites for future recurrences.

The use of radon implants (gold or platinum seeds) also presents the disadvantage of uneven distribution of radiation. The intensity is very high within a few millimeters of the implant, but the effective radiation extends scarcely more than a centimeter from the source. The even distribution of radium implants is difficult and this method has, in our experience, proved the least desirable form of treatment.

The complete surgical removal of a large epithelioma is often impracticable, particularly when the malignant process has extended to the underlying tissues. Even though the disease can be eradicated by surgery, subsequent plastic operations are often necessary which result in a long hospitalization of the patient, and are not always successful even in the most experienced hands.

The encouraging results obtained in the treatment of malignancy of the lip, mouth, and pharynx by divided daily doses of high voltage roentgen rays lead us to believe that a similar technique could be effectively employed in the irradiation of cancer of the skin. The usual 200 kv. setting has been used, with a filtration of 0.5 mm. of copper. The target-skin distances have varied from 30 to 50 cm., short distances

* The material for this paper has been collected from the Collis P. Huntington Memorial Hospital and the Pondville Hospital at Norfolk (Massachusetts State Cancer Hospital). Read at the Thirty-sixth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 24–27, 1935.

for superficial lesions and long distances for indurated lesions. The current has varied from 5 to 25 ma., depending on the capacity of the apparatus. All measurements in roentgens have been made in air without back-scattering. This type of treatment has been applied chiefly to lesions measuring more than 2.5 cm. in diameter, but occasionally to smaller epitheliomas of unusual thickness.

This method was first employed by us six years ago. A total of 85 consecutive cases which have had at least a two-year follow up period has been reviewed. An accurate statistical compilation of end-results has not proved practical. A large percentage of the patients were in the sixth

Table I

MASSIVE METHOD

Radiation Given in Two Weeks or Less

54 Cases

| Dose | 1,200 to 1,600 r | 1,600 to 2,400 r | 2,400 to 3,200 r | 3,200 to 4,000 r |
|---|---|---|---|---|
| Healed by high voltage alone | 0 | 5 | 17 | 2 |
| Healed by high voltage and radium | 2 | 3 | 2 | – |
| Not healed | 11 | 8 | 4 | – |

or seventh decade when they presented themselves for treatment, and although there was primary healing of the epithelioma, death from intercurrent disease shortly ensued. A number of cases were obviously hopeless at the outset, and irradiation was given only as a palliative measure. It has seemed best to report the results as "primary healing" rather than "cure."

The cases have been divided into two main classes: first, those that have been treated by what has been termed the "massive method"; second, those that have been treated by the "protracted method." By the massive method is meant a single roentgen-ray series completed within a period of two weeks or less, giving daily treatments of 200 to 600 r. By the protracted method is meant the prolongation of irradiation over a period of thirty or more days.

The 85 cases reviewed have had no previous operative interference, or irradiation by

Table II

PROTRACTED METHOD

Radiation Given in Thirty Days or More

31 Cases

| Dose | 2,400 to 3,200 r | 3,200 to 4,800 r | 4,800 to 6,400 r | 6,400 to 8,400 r |
|---|---|---|---|---|
| Healed by high voltage alone | 0 | 11 | 3 | 1 |
| Healed by high voltage and radium | 2 | – | – | – |
| Not healed | 6 | 6 | 1 | 1 |

other methods; 54 were treated by the so-called massive method; 31 by the protracted method. The results are given in Tables I and II. Several of the favorable cases are depicted in Figures 1 to 4.

It will be noted that dosages of 1,600 r or less are entirely inadequate. Dosages of 3,200 to 4,000 r given by the massive method may be applied to the smaller lesions, but there is danger of radiation necrosis if this amount is applied to a large area in a short time. The optimum dosage given in a period of two weeks or less is 2,400 to 3,200 r. In treating small lesions, it is now the practice to employ daily doses of 600 r; that is, the entire treatment is completed in four or five days. When the disease is more extensive, the daily dose is reduced to 300 or 400 r. The irradiation of very large lesions is often extended over a period of two or three months (protracted method), with total dosages as high as 8,000 r.

It must be understood that hard and fast rules cannot be laid down. Success in the treatment of these lesions depends upon a nice adjustment of dosage which

FIG. 1*a*. Basal cell carcinoma involving wing of nose, 2,400 r high voltage roentgen rays in daily doses of 300 r.

FIG. 1*b*. No evidence of disease six years later.

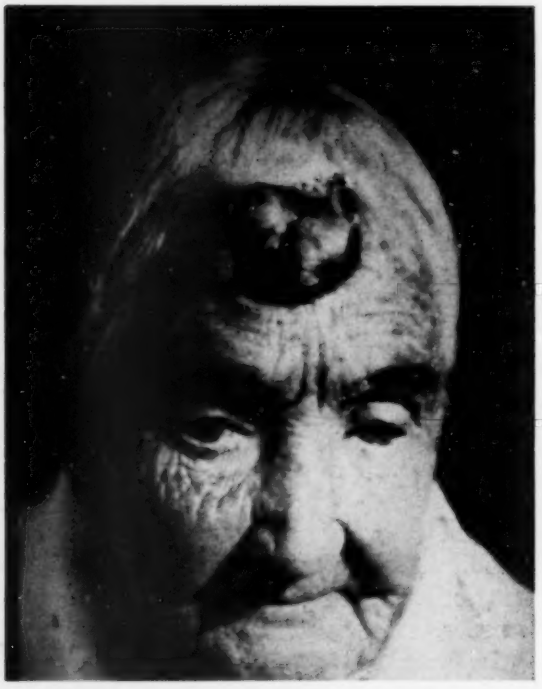

FIG. 2*a*. Epidermoid carcinoma; 2,000 r high voltage roentgen rays in daily treatments of 150 r.

FIG. 2*b*. Primary healing but daily dosage was too small and there was recurrence a year later which was treated with radium. Patient died three years later of intercurrent disease.

Fig. 3*a*. Carcinoma, probably epidermoid (biopsy not taken); 2,500 r high voltage roentgen rays in five daily treatments.

Fig. 3*b*. No evidence of disease three years later.

Fig. 4*a*. Epidermoid carcinoma; 8,400 r high voltage roentgen rays in a period of six months, plus 2,300 mg-hr. radium in platinum needles.

Fig. 4*b*. Small persistent area of radiation necrosis. No evidence of cancer. Patient died two years later of intercurrent disease.

will be sufficient to arrest the growth and still not produce permanent radiation damage. There has been surprisingly little difficulty from necrosis of underlying tissues. The response of basal cell epitheliomas has been rather more favorable than that of the squamous cell variety.

It should be mentioned that the clinical differentiation between basal cell and epidermoid carcinoma is unreliable, and a biopsy should be done in all instances. A close follow up should be kept on the cases and if recurrences develop, they should be immediately treated. Recurrences are usually small and can be handled by direct application of radium, or by intensive doses of long wave roentgen rays.

SUMMARY

Daily divided doses of high voltage roentgen rays afford the best method of irradiating large cancers of the skin; healing is often effected when other procedures fail.

A more uniform dosage can be applied to the area of malignant disease than is possible with radium needles, radon implants, or low voltage roentgen rays.

There may be some virtue in the more selective action of the short wave lengths resulting from high voltage and heavy filtration, as compared with the longer wave lengths of low voltage and light filtration.

Lesions not exceeding 2.5 cm. in diameter may be given daily doses of 600 r with a total dose of 2,400 to 3,000 r.

Larger lesions are treated with daily doses of 300 to 400 r, the total dose being about 3,000 r.

When treating very extensive growths it may be necessary to extend the irradiation over a period of two or three months with total dosages as high as 8,000 r.

The results in eighty-five consecutive cases treated by this method are reported.

DISCUSSION

DR. B. P. WIDMANN, Philadelphia. This has been a very splendid presentation. Dr. Dresser has given us an experience extending over a period of six years, and besides being very interesting, it is particularly valuable and important from the standpoint of the progress that is being made in irradiation procedures today. It is particularly important because he has used high voltage rays, 200 kv. and 0.5 mm. of copper, which I know most of us some time ago would have thought useless. He has shown results that I think are comparable with anything obtained with the conventional procedures using the same voltages with varying thicknesses of aluminum, from 1 up to 6 mm. of aluminum. I am sure his results are comparable to any results obtained with radium of varying qualities.

I know that some of the results which Dr. Dresser has obtained in certain selected instances, particularly where there has been deep infiltration of long duration, especially with exposed bone and cartilage, are superior to many of the results we obtained in the past with the so-called conventional techniques.

Our experience has been very favorable with Dr. Dresser's technique in a few selected cases. The treatment had been for lesions of the so-called resistant type which I think were primarily under-treated lesions, or the recurrent lesions, but we have found this treatment especially valuable where there has been infiltration. We have not used it extensively except for the recurrent lesions, but I am convinced, and have been for a long time, that the problem is not so much a question of the quality of ray as it is the quantity of ray.

Some time ago, about eight years ago to be exact, we treated a series of lip cancers in which the extent of involvement was slight, but we elected to treat cases equally involved. We used low voltage rays, 120 kv., and varying thicknesses of aluminum from 1 up to 6 mm.; then 0.5 mm. of silver and brass; then 0.5 mm. of silver and lead with an equivalent density of 3 mm. of platinum. The results were uniformly good. We estimated all received 5 erythema doses. In the so-called resistant cases which I believe are frequently under-treated cases, the good results with additional treatment have been because more radiation was given and there seems to have been a better tolerance of the shorter wave length radiation, probably because of the difference in penetration and absorption.

In relatively superficial lesions, where the

question of depth dose is not a serious factor and especially with lesions that are not too extensively infiltrating, it makes no practical difference about the quality of radiation employed, the result of treatment depends entirely upon the quantity of radiation. The problem of estimating the dose is still a more or less empirical procedure because the extent of infiltration is a problem of clinical judgment.

There is sufficient clinical evidence supported by physical measurements to indicate that short wave length radiation is more penetrating, gives greater depth absorption and is apparently tolerated by the tissues, especially by the skin, much better than long wave length radiation. These factors offer an advantage that should make this procedure of short wave length irradiation of superficial lesions popular particularly with the advent of shock-proof equipment that can be easily adjusted and with the high current facilities that will greatly diminish the time of treatments.

Dr. Dresser (closing). I want to thank Dr. Widmann for his kind discussion of this paper. I do agree with him it is a question of quantity rather than quality of radiation. I think our failures in the past with low voltage radiation have been due to the fact that we gave the surface of the tumor a tremendous dose, but due to the rapid falling off in intensity of the long wave lengths as you go into the depths the base of the lesion did not receive enough dosage and, therefore, we got recurrences. The very good results that were obtained from the implantation of platinum needles were due to the fact that we get the radiation at the base of the tumor rather than over its surface.

# DEVELOPMENTAL CHANGES FOLLOWING IRRADIATION*

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MOST articles referring to change in tissue following irradiation deal with those results observed within a few months after exposure; others consider it entirely from an experimental standpoint, and, with the possible exception of telangiectasis, very little attention has been given conditions viewed from a clinical standpoint to late changes which may be observed.

To illustrate this, the statement was made at a recent meeting, that a large abdominal tumor, in a young child, was treated with some damage to the surrounding structure but, in time, it was hoped the normal character would return.

It is the purpose of this paper to present a series of incidents in which the immediate results of treatment were satisfactory, so far as the disappearance of the disease was concerned. But years afterward there were unusual and noticeable changes, which, in some instances, amounted to deformity. Naturally, most of these cases were children, but adults do not escape. Marked atrophic changes have been noticed following the treatment of acne on the faces of several women. In both women and children the arresting of the disease was perfect at time of treatment and the patient suffered only a mild erythema. But five or ten years afterward there were marked signs of atrophy of the facial tissues although telangiectasis was not apparent.

It is well known that in some cases a very small amount of irradiation is required to check bleeding and suppress menstruation. If a small dosage can produce these results what might be the consequences from repeated and prolonged routine examinations to which some patients are subjected for diagnostic purposes, especially children?

Attention to the lack of development following irradiation was noted when reexamining the results in a number of cases treated for angioma, after a lapse of about ten years.

The distortion was especially noticeable about the mouth. Shortly after treatment this organ presented a normal contour, but years later some puckering at the site of treatment was quite evident. Where masses of considerable size about the nose had been irradiated there was no later distortion of the tissues.

It is very difficult to determine whether the lack of development was due to the irradiation or to the replacing of the normal tissues by the tumor.

This conflicting point is by no means easy to determine and may be illustrated by the following observation. In the case of a port wine stain, where the vessels are small, and it would be supposed that there was very little tissue change; if gently pressed so as to deplete the blood vessels to bleach the part, it will be found to lack the sound feeling of the surrounding skin and a decided pitting is produced.

It is also noted, but much more exaggerated, in the cavernous type. This, to some extent, explains the poor results in the treatment of these supposed superficial cases. The depth of these vascular changes in the tissue is not realized and in many of them the underlying bone may be involved. In one case, reported a few years ago, the discoloration was faint but uniform over the entire arm and shoulder. Roentgenograms showed the bones to be larger on the affected side. For this reason, treatment was not given, although, in this instance, the bone structure was apparently normal. The shafts of the bones and the cancellous portion compared favorably with the other, normal arm. If the bone is involved in the

* Read at the Twentieth Annual Meeting, American Radium Society, Atlantic City, N. J., June 10–11, 1935.

cavernous angioma the vascular changes partake of the same type, and naturally the treatment in such cases would depend upon the extent of the involvement.

An analogous case of megalodactylism, treated for Dr. Rugh, presented a somewhat different condition: all the tissues suffered an excess growth, but it was confined to the second toe.

In the foregoing instance the tissue change was limited in extent and in no way interfered with the function of the part, due primarily to the fact that the area of irradiation was restricted.

In some other fields, in which it has been necessary to treat for a malignant tumor, the end-results have been distressing, but, unfortunately, at the present time it is difficult to see how they could have been avoided.

The following short synopsis illustrates a typical case.

A boy, aged two, healthy, except for a firm, hard, fixed tumor, 5 cm. in diameter, on the right side of his neck. The trouble began ten months before admission. Five months after the onset, the tonsils and adenoids were removed; they were thought to be the probable cause of the tumor. The patient was then referred for roentgen treatment, which had no effect upon the growth. At this time he entered the Presbyterian Hospital and Dr. Brown attempted to remove the mass but found it was too deep. A section was taken for examination. Dr. Eiman reported it to be a fibrosarcoma; this was confirmed by Dr. Allen J. Smith. A month later the case was referred to the Oncologic Hospital for treatment. A 100 mg. radium pack was employed, filtered by 3 mm. lead, elevated 1 cm. on wood. This had no effect upon the mass. Then six glass seeds 3.5 mc. each were introduced into the mass and this reduced it considerably. Three months later six more seeds of 4.5 mc. were inserted. This caused the mass to break down. Considerable necrotic tissue was removed, followed by a deep ulcer. Four months later the posterior edge was again treated by cross-fire, 100 mg. being used for fourteen hours. The ulcer then healed slowly and the tumor disappeared. Six years later he was brought in for plastic work to correct, to some extent, the deformity caused by the irradiation. At that time the head was drawn quite perceptibly to the right side. There was a lack of development of the inner end of the clavicle, the right side of the cervical vertebrae, and to some extent the right side of his face (Fig. 2). At the same time the original section of the tissue was studied.

Dr. Fred Bothe agreed with the original diagnosis of Dr. Eiman and Dr. Allen J. Smith. Dr. Joseph McFarland thought it to be a

Fig. 1. Atrophy of the skin following treatment for acne.

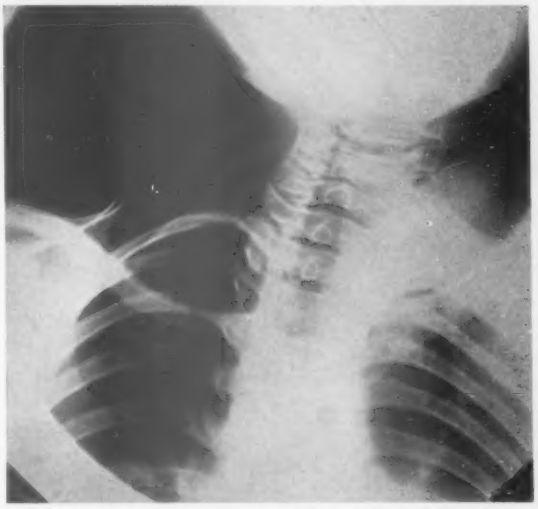

Fig. 2. Atrophy of bones on right side following application of radium.

Fig. 3. Atrophic changes about hip following irradiation in infancy. Fracture at the age of sixteen years.

mixed fibroma, while Dr. Hueper found it to be a fibroma.

The interesting fact in this discussion was the pertinency of the original course of treatment. There has been no recurrence and the plastic operation has considerably improved the boy's posture. Unfortunately, the involved bones cannot be expected to grow.

Another case of the same character was seen through the courtesy of Dr. A. Bruce Gill. The history of the case stated that when an infant the child developed a tumor of the thigh. This was removed surgically and found to be a fibrosarcoma, which recurred in a very short time. It was then treated by roentgen rays and radium. At about eight years of age she suffered from a fracture of the femur, and the roentgenogram showed it to be at the junction of the upper and middle third. The femur, generally, presented the appearance of a bone after several months of treatment for fracture. The upper third, however, was very small and narrow compared with the lower two-thirds, which was about the same size and width of the normal leg. The pelvic bone on the diseased side showed the same lack of development (Fig. 3). For a number of years this girl had been able to get about and even swim, with this greatly shortened limb. At the age of seventeen there was a recurrence of the tumor and the microscopic examination proved it to be a sarcoma of about the same type as the original.

This marked lack of development appeared again in the bones of the fingers of a case referred by Dr. W. Edward Chamberlain. In this instance there was a cavernous hemangioma, with unusually large heavy vessels, involving the little finger and ring finger, and extending to the wrist. Radium had been applied with very little effect upon the tumor, which in all probability was due to the fact that these superficial vessels were closely associated with the larger blood channels in the bone. While there was no decrease in the size of the tumor there was a very marked lack of development in the bones of the little and ring fingers. At the present time the fingers on the affected side are much smaller than the normal hand (Fig. 4).

In contrast to the cases just cited might be mentioned a sarcoma (probably giant cell) of the sacrum, in a child about ten years of age, treated for Dr. Rugh. Here, as shown by the roentgenogram, was a marked destruction of the sacral bone. After the application of 100 mg. of radium for twenty-four hours the mass entirely disappeared and the bone structure was restored to the extent that it was impossible to tell which side the tumor had involved. The patient did not return for observation and

Fig. 4. Atrophic change in the bones of the hand following the application of radium. The hemangioma was not benefited.

about three years later was reported to have died of a recurrence. It would have been of interest to follow this child to maturity and note the effect of irradiation upon the bone structure.

COMMENT

The greatest degree of atrophy has occurred chiefly among children treated during infancy or at least before the third or fourth year. The effect of this retardation becomes less with age and the character of these changes resembles those seen in the adult.

From the review of the facts, as here stated, there is a well grounded suspicion that these atrophic changes have not been recognized to the degree that the subject seems to warrant. In most instances these changes have occurred where intense irradiation was required for the relief of some malignant process. They seem to have been somewhat greater when the disease was situated over or near the epiphyseal end of the bones. But they have also been observed in cases where angiomata have been treated with a comparatively small amount of irradiation. The lips often showed this lack of development while it was not seen in similar cases upon the nose, even when quite large tumors were treated.

This subject has another angle, not entirely within the scope of this article but bearing directly upon it, which is the possible effect from prolonged and frequent roentgenographic examinations of young children where they are referred from one hospital department to another. Usually no record is made of the amount of exposure and while there may be only a faint tanning of the part its frequent repetition must undoubtedly cause some effect upon tissue development.

In the adult these atrophic changes may lead to very marked alterations of structure and function, but the deformities seen in young children are not so likely to occur. Under some circumstances the change of structure and function may be desired but great care must be taken not to include adjoining organs.

In closing, it must be admitted that there are late changes in tissue following irradiation and at the present time there is no possible way to avoid them. But where prolonged and intense irradiation is necessary these effects should be thoroughly understood.

DISCUSSION

Dr. G. M. Dorrance, Philadelphia. I think I have had more than my share of these deformities of all kinds, and suppose that is because I have been associated with the radiologists for a good many years. I do not know why else I should have seen so many. In the late results there are changes in the tissues from the skin and bone, and I have seen all grades of these particularly of the muscles of the face. I am glad I am not seeing so many of these cases now, probably due to the change in treatment. I have seen the changes in the bone that Dr. Newcomet mentioned but practically all these treatments were given to children and the bones did not develop. I have seen them in the pelvis, in the hands, fingers, toes, clavicle, and particularly in the side of the face. I have seen them occur from both radium and roentgen therapy, and they occur some years after treatment. The men who give the treatment often do not see them. The cases are very distressing for nothing can be done for them. They are due to overdosage; I think very heavy dosage was used in practically every case I have seen. I agree that carcinoma should be treated with heavy dosage, but I wish to make a plea for lighter treatment in angiomata. These changes do not occur in the adult to the same degree and I am sure they are due to treating with too heavy dosage.

Dr. George E. Pfahler, Philadelphia. I think we must not lose sight of the fact that in treating a patient the first duty is to get that patient well. This first patient with atrophy and fracture of the thigh was treated by me. The patient was then four years old and is now seventeen. I think the fact that the child is alive thirteen years after a recurrent fibrosarcoma is worthy of compliment rather than condemnation. The fact that we gave large doses proves that it was necessary, and the fact that there is a recurrence thirteen years afterward only shows that we did not give quite enough of it and did not go quite far enough around. If it is a question of letting the child die or

treating sufficiently to cause atrophy, I believe the right thing to do is to save the child's life. It is advisable to warn the family that such a thing may occur, and I think whenever we treat over the epiphyses lack of development may occur even though we get the patient well.

I reported several years ago a giant cell tumor case with a similar result. There was lack of development of the shoulder of the side affected, but what was better to do for that patient even though there is an atrophy. The patient is happy, comfortable and developing normally in school. In treating serious conditions I think we should not be too much afraid to treat sufficiently. In treating angiomata I think we should perhaps be cautious, but only to the degree of getting the patient well even with the possibility of some damage.

Dr. Rollin H. Stevens, Detroit. Last year at the meeting of the Radiological Society I reported the case of an infant I had treated for nevocarcinoma. The child was five months old and apparently had been born with this growth for one side was much larger than the other at birth. I gave a heavy roentgen treatment, 200 kv., at the request of the doctors in charge of the case and of the parents. I explained that the child would perhaps not develop very well and that the ovaries would be destroyed. I saw the child again last year and there was shortening of the tibia and fibula although I never treated those bones, only treating the femur. There was a shortening of 2 inches on one side, showing that the lack of development affected not only the bone treated but also the tibia and fibula which were not treated.

Dr. Edward H. Skinner, Kansas City, Mo. I wish to take a philosophical exception to the point of Dr. Pfahler and Dr. Stevens regarding children who have been treated and achieved prolongation of life but without a paralleling prolongation of happiness or comfort. The human species is not in such a precarious condition at present that it could possibly vanish from the earth's surface. It is hardly justifiable to interfere too much with the biologic career of normal tissues by the treatment of tumors or congenital variations. Without making the statement as dogmatic as Dr. Pfahler's, "that we should treat to cure the disease," my point is, that we should treat the patient with the disease so that he may ultimately be a happy and useful biologic unit of the genus *Homo*.

Dr. Maurice Lenz, New York City. Has Dr. Newcomet ever observed the occurrence of tissue changes he described after radium without preceding treatment, or after destruction by heat? In other words, how much deformity of the tumor bed is due to the absorption of the tumor, connective tissue replacement, pressure atrophy and how much to radiation effect?

Dr. Newcomet (closing). In reference to the cases here cited, these tumors, which recurred after operation, would have proved fatal if they had not been so treated. The conditions were explained to the parents and they were not only willing to take the risk but most grateful for the results. Dr. Pfahler's patient has been happy and could even swim with that shrunken limb.

We fully recognize that these changes happen when the disease is chiefly around the epiphyseal edge of the bone. In the several cases treated some years ago one could scarcely see any change from normal.

If Dr. Skinner can write us a prescription whereby the disease can be relieved without damage to the tissues every one will be thankful.

In regard to the question by Dr. Lenz: All these cases were treated from five to fifteen years ago and at that time this lack of development, due to irradiation, was not recognized. At present, treatment is not pushed to the extent that it was formerly, and when the patient matures the puckering of the lips and the shriveled tongue are less likely to occur. The treatment of these cases is now prolonged for several years and only vigorous irradiation is used when the angioma is growing rapidly. After the disease is controlled the amount may be reduced and the treatment extended over a period of years.

Vol. 36, No. 3

# THE USE OF LONG TARGET-SKIN DISTANCES IN ROENTGEN THERAPY*

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OF THE physical factors which must be considered in any plan of roentgen therapy, only two, the filter and the distance, may, in general, be modified at will. Voltage and milliamperage are dependent on the type of apparatus available; field size is determined by the anatomical location of the lesion to be treated; the time is decided after all the other factors are established.

The effects on the distribution of the radiation within the tissues of changing the filter and of changing the distance have been shown to be independent of each other.[1] It is therefore possible to investigate each alone. Recently there has been considerable discussion of the value of increasing the target-skin distance considerably over those ordinarily employed. The object of the present paper is to investigate the possible advantage of such a change in technique, and to see whether an optimum distance can be established, in any particular case.

Changing the target-skin distance has two effects which are important in radiation therapy. To a certain extent, it alters the relative depth dose, and to a much greater extent it varies the time required to deliver a specified amount of radiation. Any discussion of long target-skin distances must consider both of these points.

The change in depth dose is due to purely geometrical considerations, can be determined accurately, and used as a basis for definite dosage calculations. The change in time, on the other hand, involving changes in the rate of administration, and frequently in the amount of both the daily and total doses, can be discussed only from a biological point of view.

For the study of the physical side of the question, the depth dose was measured in a paraffin phantom, for distances of 50, 100, and 150 cm., and a variety of fields ranging from 10 to 250 sq. cm., with filters of 0.5 and 2.0 mm. of copper. According to these data, the relative depth doses, for all fields and both filters, varied (within the limits of experimental error) with the distance, in accordance with calculations made on the basis of the inverse square law, as shown in Figure 1.

In this figure, the increase in depth dose is shown with increase in target-skin distance beyond 50 cm., for several depths. In all cases the depth dose for the 50 cm. distance is taken as 100 per cent. The lines pass through the calculated* values for 70, 100, 125, and 150 cm.; the circles represent the experimental results at 100 and 150 cm. target-skin distance. Each of these is the average of the values for several fields, ranging from 25 to 250 sq. cm. The size of the circle indicates the range of values for different fields. For all depths, the experimental value is 1 or 2 per cent higher than the calculated at the 100 cm. distance. At 150 cm. the variation is not systematic. In any case, it is so small that it can have no significance from the point of view of radiation dosage.

* The method of calculation for the increase in depth dose, for any field, depth, and distance, over that for the 50 cm. distance, may best be described by means of an example. To calculate the increase in depth dose at 12 cm. depth, with any given field, as the target-skin distance is increased from 50 to 150 cm.: For any given irradiation, the surface dose at 150 cm. is $\frac{(50)^2}{(150)^2}=\frac{1}{9}$, or 0.111 of the surface dose at 50 cm. The dose at 12 cm. depth for 150 cm. is $\frac{(50+12)^2}{(150+12)^2}=0.146$ of that for 50 cm. The improvement in depth dose, therefore, is $\frac{0.146}{0.111}=1.32$. Or, if the depth dose at 50 cm. is taken as 100 per cent, that at 150 cm. is 132 per cent. The gain with the distance is the same for all fields (the size of the field does not enter into the calculations) but varies, of course, for different depths.

* Read at the Thirty-sixth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 24–27, 1935.

On this basis, therefore, if depth doses are known for the 50 cm. distance, they can be calculated for any other, up to 150 cm. at least. For instance, the depth dose for a 100 sq. cm. field, with 0.5 mm. copper filter, at 200 kv., and 50 cm. target-skin distance, is 38 per cent, at a depth of 9 cm. At 100 cm. distance, from the curve of Figure 1, it is 117 per cent of this or $1.17 \times 38$, $=44.5$.

to tumor depth. For small values of the latter ratio (representing relatively short distances and deep-seated lesions) the former ratio (or depth dose) increases rapidly with the distance, but after distances of about 10 to 12 times the tumor depth, the curve flattens considerably. This would be, for example, after 100 to 120 cm., for a 10 cm. depth. Evidently for such a calculated depth dose, when neither absorption nor

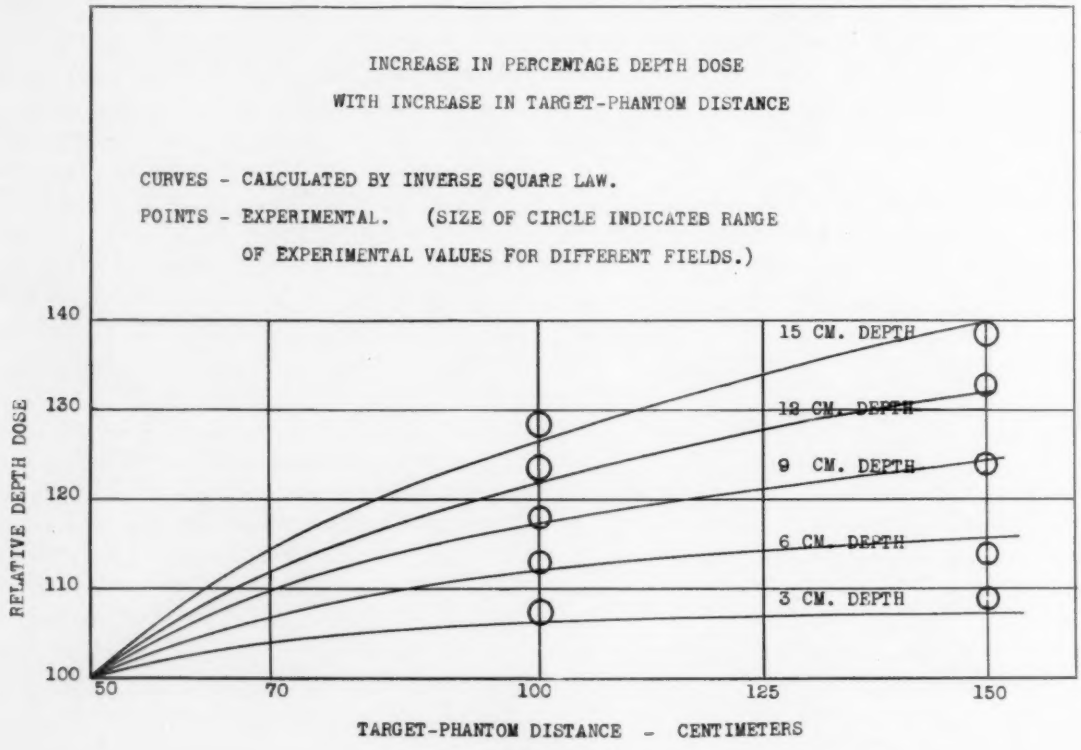


Fig. 1

From the curves it is noticeable that, no matter how great the distance, the increase in depth dose for small depths is insignificant; the improvement becomes more and more important with increasing depth. This is to be expected, and the distance to which it is profitable to go can readily be found. If there were no absorption or scattering of the radiation by the tissues, the depth dose would be exactly the ratio of the squares of the target-skin and target-tumor distances. The upper curve in Figure 2A shows how this ratio changes in relation to the ratio of target-skin distance

scattering is considered, the optimum distance would be about 12 times the tumor depth; after that, further gain would be slow. Now, for any given tumor depth, since the quality of the radiation is not changed by increasing the distance, the effect of the intervening tissue on the radiation will be about the same for all distances, and taking account of it would simply reduce all the points on this curve by the same percentage. This has been done for a tumor depth of 9 cm., from the experimental values, and the results given in the lower curve. It is still apparent that im-

provement is much slower after a distance 12 times the tumor depth.

In Figure 2B are the actual values for 6, 9, and 12 cm. depths, plotted in terms of the ratios under discussion. It has been impracticable to cover experimentally as great a range as in the calculated curve, but it is still evident that the increase in depth dose slows down as the distance ratio exceeds 12. This indicates that there is little advantage in going beyond 100 to 150 cm., even for very deep-lying lesions.

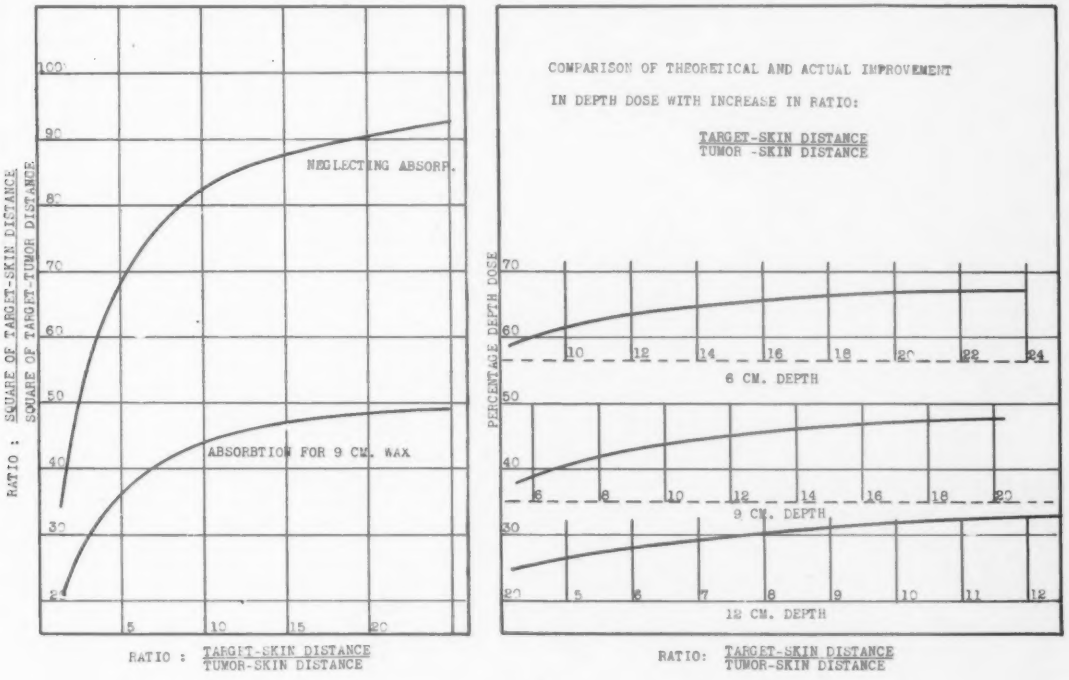
RATIO : SQUARE OF TARGET-SKIN DISTANCE / SQUARE OF TARGET-TUMOR DISTANCE
NEGLECTING ABSORP.
ABSORBTION FOR 9 CM. WAX
RATIO : TARGET-SKIN DISTANCE / TUMOR-SKIN DISTANCE
A
COMPARISON OF THEORETICAL AND ACTUAL IMPROVEMENT
IN DEPTH DOSE WITH INCREASE IN RATIO:
TARGET-SKIN DISTANCE / TUMOR -SKIN DISTANCE
PERCENTAGE DEPTH DOSE
6 CM. DEPTH
9 CM. DEPTH
12 CM. DEPTH
RATIO: TARGET-SKIN DISTANCE / TUMOR-SKIN DISTANCE
B

FIG. 2

It must be remembered that in order to produce these improvements in percentage depth doses, it is necessary to increase the time of the irradiation in accordance with the inverse square law. That is, to increase the depth dose at 10 cm. by 19 per cent, by increasing the target-skin distance from 50 to 100 cm., it is necessary to use an irradiation 4 times as long. To increase it by 26 per cent, by going to 150 cm., requires 9 times the irradiation.

It is interesting to consider some practical examples of the value of increasing the distance. Two such are outlined in Figure 3. The depth doses for 100 and 150 cm. distances have been calculated from published values for 50 cm.*[1] For the intraoral lesion, assume a neck diameter of 12 cm., and an irradiation through two fields of 50 sq. cm. each, as shown, and consider the doses delivered on the skin and in the midline. At the 50 cm. distance it is seen that 53 per cent of the skin dose reaches the midline; about 15 per cent passes through. Hence, from a total of 100 per cent to each field, each skin surface receives a total of 115 per cent, while the midline receives 106 per cent. If the target-skin distance is increased to 100 cm., each skin surface is found to receive 120 per cent and the midline 118. This represents an improvement for the midline of 12 per cent, an increase in the skin dose of 4 per cent, or a net increase for the midline of 8 per cent. And in order to achieve this, it is necessary to multiply the irradiation time by four.

* Depth doses measured in a water phantom have been shown to be the same as those in the human body,[2] while those measured in a paraffin phantom are considerably higher.[3] Therefore, instead of using depth doses determined directly in the course of this work, all of which were in paraffin, it has been considered better to use values based on water phantom measurements.

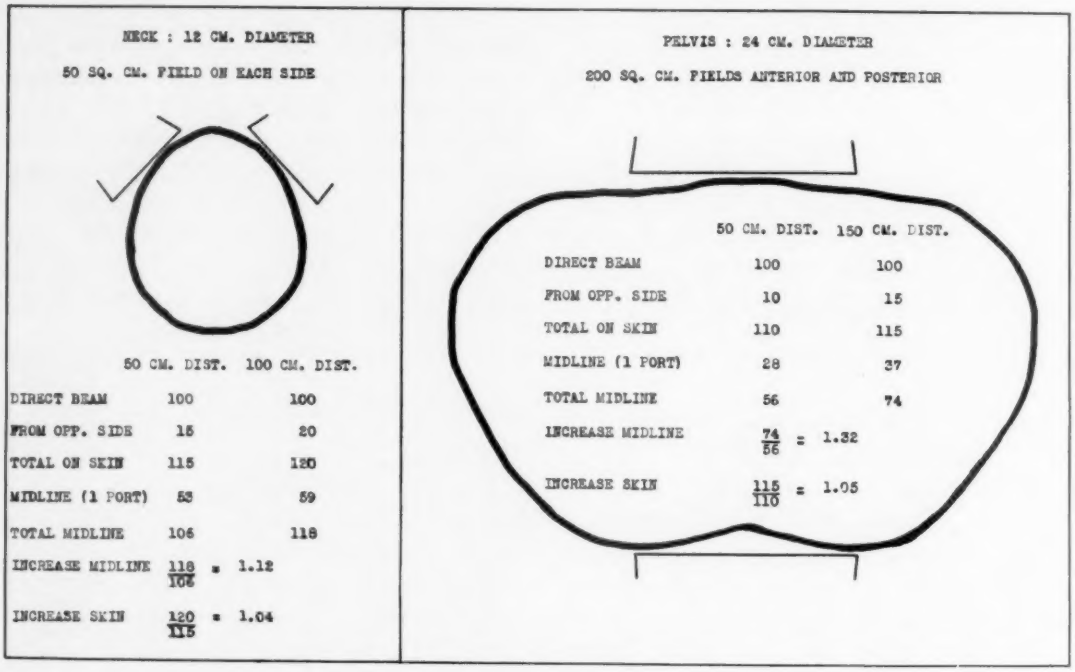
NECK : 12 CM. DIAMETER
50 SQ. CM. FIELD ON EACH SIDE
50 CM. DIST. 100 CM. DIST.
DIRECT BEAM 100 100
FROM OPP. SIDE 15 20
TOTAL ON SKIN 115 120
MIDLINE (1 PORT) 53 59
TOTAL MIDLINE 106 118
INCREASE MIDLINE 118/106 = 1.12
INCREASE SKIN 120/115 = 1.04
PELVIS : 24 CM. DIAMETER
200 SQ. CM. FIELDS ANTERIOR AND POSTERIOR
50 CM. DIST. 150 CM. DIST.
DIRECT BEAM 100 100
FROM OPP. SIDE 10 15
TOTAL ON SKIN 110 115
MIDLINE (1 PORT) 28 37
TOTAL MIDLINE 56 74
INCREASE MIDLINE 74/56 = 1.32
INCREASE SKIN 115/110 = 1.05

FIG. 3

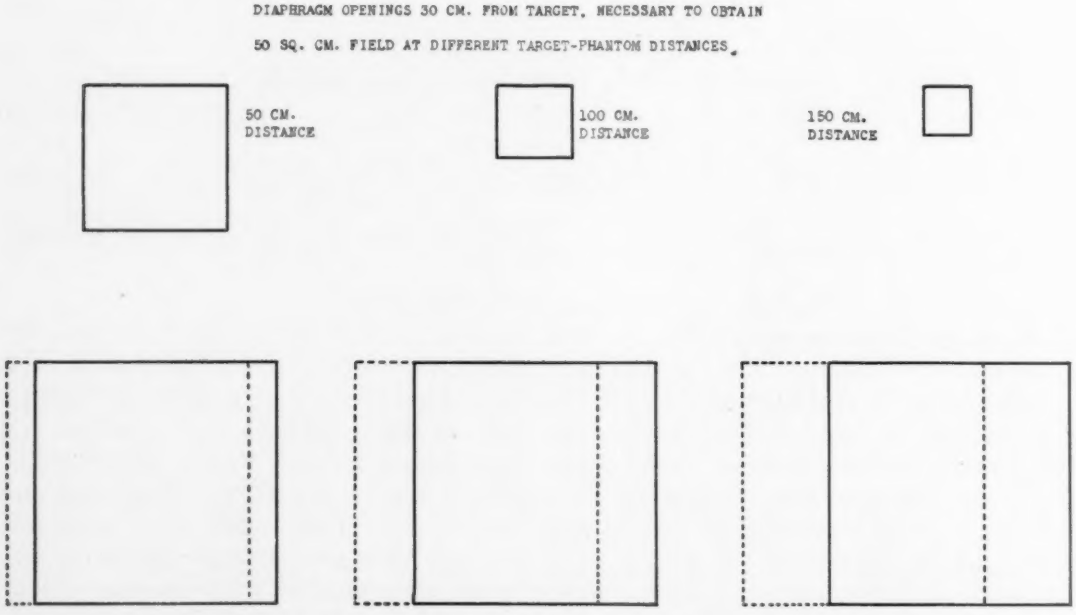
DIAPHRAGM OPENINGS 30 CM. FROM TARGET, NECESSARY TO OBTAIN
50 SQ. CM. FIELD AT DIFFERENT TARGET-PHANTOM DISTANCES.
50 CM. DISTANCE
100 CM. DISTANCE
150 CM. DISTANCE
DOTTED SQUARES SHOW DISPLACEMENT OF FIELD FOR 0.5 CM. DISPLACEMENT OF DIAPHRAGM.

FIG. 4

On the other hand, consider a point approximately in the middle of the pelvis. Here, as shown in the data tabulated on the figure, an increase in target-skin distance from 50 to 150 cm. results in an increase of one-third in the total dose delivered to the lesion, with a practically negligible (5 per cent) increase on the skin.

Again, however, in order to obtain this increase in the depth dose, it is necessary to multiply the irradiation time by nine.

With regard to the clinical effect of the increase in time, or diminution of intensity, resulting from such a change in technique, there is little definite data. With 200 kv. roentgen rays, 0.5 mm. copper filter, it has been found that if radiation is delivered at the rate of 20 to 60 r per minute, the threshold skin dose is about 500 r, but if the intensity is dropped to about 3 r per minute, with no change in quality (by changing milliamperes), the threshold dose is increased to 600 r. That is, with the specified reduction in intensity, or corresponding increase in time, there is an increase of 20 per cent in the amount of radiation necessary to produce the threshold skin reaction. This change of intensity is in the range of that which occurs when the distance is increased from 50 to more than 100 cm., with a filter of 1.5 or 2.0 mm. of copper. That is, because of intensity changes accompanying a change in distance, phenomena of tissue recuperation begin to manifest themselves more markedly during the course of a single treatment. It is, of course, significant whether or not this recuperation is the same for the skin and the diseased tissue. This is a clinical problem, and can only be solved by experience.

Additional complications of this sort arise from the fact that when the distance is increased the daily dose is frequently decreased. This means an extension of the total time, as well as a decrease in the intensity of the individual treatments, and the problem of the relative recuperation from the total dose, as well as that during the administration of the partial ones, must be considered. These considerations furnish the explanation of the statement sometimes heard that patients tolerate better radiation administered with long target-skin distances.

It seems to be a matter of clinical agreement that radioresistant lesions respond better to long-continued irradiation, that is, to small daily doses spread over a considerable period of time.[4,5,6] For such cases, especially when the tumor mass is deep-seated, a long target-skin distance would be desirable. On the other hand, for radiosensitive lesions, it is not so valuable, except in cases where it is desired to include a large part of the body (possibly the entire trunk) in a single field. With the tube holders in general use at present, this is possible only at great distances because of the mechanical limitation of the diaphragm system.

The question of relative field and diaphragm sizes brings up the consideration of the necessity of careful localization of the beam. Figure 4 shows the relative diaphragm sizes, at 30 cm. from the target, necessary to obtain a 50 sq. cm. field at 50, 100, and 150 cm. target-skin distances. The dotted squares show the displacement of the irradiated area, for a displacement of 0.5 cm. at the diaphragm. Of course, the greater the field, the less significant this becomes, but it is evident that at long distances much more accurate means of setting up the patient and of keeping him quiet are necessary than with shorter distances.

## SUMMARY

It has been shown that relative depth doses for various target-skin distances can be calculated according to the inverse square law. If actual depth doses are known for any distance, they can be calculated for any other, between 50 and 150 cm., at least. The increase in depth dose with distance is small near the surface, and becomes steadily greater with increasing depth. It is not, however, advantageous to use distances greater than 10 to 12 times the tumor depth. It is known that the time necessary to deliver a specified amount of radiation increases as the square of the distance. From a practical point of view, this increase in time is an important economic factor. From a biological aspect, it introduces complications because of differences in tissue recuperation. It would

be expected to make the use of long distances more valuable in radioresistant than in radiosensitive conditions. The problem of localization of the field with regard to the lesion becomes increasingly important with the use of longer distances.

I wish to acknowledge my indebtedness to Mr. L. D. Marinelli for his assistance throughout the physical experiments, and to Dr. A. N. Arneson for the study of the effect of change in intensity on the threshold skin dose. I also wish to express my appreciation to Dr. G. Failla for his suggestions during the development of the problem.

## REFERENCES

1. FAILLA, G., and QUIMBY, E. H. The economics of dosimetry in radiotherapy. AM. J. ROENTGENOL. & RAD. THERAPY, 1923, *10*, 944–967.
2. QUIMBY, E. H., COPELAND, M. M., and WOODS, R. C. The distribution of roentgen rays within the human body. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *32*, 534–551.
3. QUIMBY, E. H., and ARNESON, A. N. A comparison of paraffin and water phantoms for roentgen-ray depth dose measurements. AM. J. ROENTGENOL. & RAD. THERAPY. To be published.
4. COUTARD, H. Principles of x-ray therapy of malignant diseases. *Lancet*, 1934, *2*, 1–8.
5. HOLTHUSEN, H. Die biologischen Grundlagen der Langzeitsbestrahlung. *Strahlentherapie*, 1931, *42*, 881–898.
6. NIELSEN, J. Ueber Coutards Röntgenbehandlung maligner Tumoren. Ideologie, Prinzipien, praktische Anwendung, Resultate, Entwicklungsmöglichkeiten. *Strahlentherapie*, 1935, *53*, 25–53.
7. MARTIN, H. E., and LENZ, M. A symposium on the treatment of pharyngeal cancer by the divided or protracted dose principle of external radiation. *Radiology*, 1935, *24*, 364–368.

## DISCUSSION

DR. HARRIET C. MCINTOSH, New York City. I have treated a small group of cases at 100 cm. distance. I want to present two cases in which I tried two contrasting techniques on the same patient. In one of them I considered the result worth while, and in the other I did not.

The first patient was an Italian women, aged sixty-five, with epidermoid carcinoma of the cervix, graded International II, Schmitz III, with a badly infected cervix and a plus four Wassermann. The following technique was used:

*Factors Common to Both Sides*

Identical fields—16×12 cm. each

Same amount—100 r daily to 1 anterior and 1 posterior field daily; opposite sides on alternate days 200 kv. (peak), 30 ma., 2.45 mm. aluminum used with copper

*Factors Varied on Two Sides*

| | Right | Left |
|---|---|---|
| Filter | 0.5 mm. Cu | 2 mm. Cu |
| Distance | 70 cm. | 100 cm. |
| r per minute | 28.5 | 5.9 |
| Duration of treatment | | |
| per area | 3 min. 25 sec. | 17 min. |
| daily per side | 6 min. 50 sec. | 34 min. |
| Total duration | 8 weeks 3 days | 9 weeks 5 days |
| Total r per field | 2,500 | 3,000 |
| *Depth dose at 11 cm. | 36 per cent | 39 per cent |

* At center of each pelvic field
Sagittal diameter of patient 22 cm.

The group of factors given on patient's right side represents my usual technique except that 200 r per field is ordinarily given instead of 100 r. I have deviated from the terms of Mrs. Quimby's present study by changing the filtration as well as the distance, but I was interested not only in obtaining maximum depth, but in making the intensity range as wide as possible; 39 per cent as against 36 per cent represents an improvement of about 10 per cent in depth dose. Mrs. Quimby tells me this improvement is due to the distance only, improvement in depth dose from change of thickness of copper being practically negligible. In respect to intensity, however, the situation is quite different, the copper bearing a little more than half the responsibility for the lowered intensity as against the distance. Mrs. Quimby stated in her paper that 20–60 r/min. gives a threshold erythema at 500 r, while 3 r/min. requires 600 r. My intensities are near these limits, and my total r is in the same ratio of 5 to 6.

At conclusion of treatment there was desquamation in right groin. Four weeks after treatment the groin was healing on right, desquamation had spread to upper part of field. There was a similar condition on posterior fields. No desquamation at any time on left; no itching, no marked sense of heat; moderate erythema only, followed by pigmentation. Effect on interior of pelvis as follows: Infection cleared rapidly, with no rise of temperature in early stages of treatment, and disappeared before treatment was over. Clinical note two

months after conclusion of treatment: Cervix normal in appearance. Fornices practically obliterated by contraction. Slight thickening in left parametrium, no gross evidence of disease.

The value here seems to be the delivery of 3,000 r through two opposite pelvic fields without a particle of skin desquamation. The toleration of the badly infected pelvic structures is probably explained by the slow delivery on both sides, 100 r per field daily. It would have been interesting to be able to show greater regression of disease on the left side than the right, but there is probably enough scattering effect so that this would be an unreliable deduction, even if I were able to present it as a fact.

The second case was frankly experimental. The woman had metastasis from carcinoma of the breast in almost every bone of her body except hands and feet, and one would not ordinarily waste time and tube hours on such a procedure. But from her mid-dorsal to 5th lumbar, her vertebrae all happened to be involved in an unusually uniform manner, without bad crushing, so I covered them with two 8×10 cm. fields. There is not time for much detail, but the important factors were:

Upper field, 200 r daily, 0.5 mm. Cu, 50 cm. distance, total 2,000 r.

Lower field, 100 r daily, 2 mm. Cu, 100 cm. distance, total 2,000 r.

In the first case, therefore, the daily r per field was the same—the total r different. In this case the daily r was different—the total the same. In this case also the variation in distance was greater, as 1 to 2.

Films made after two months showed moderate filling in of the vertebrae in both fields, the lower no more than the upper. The skin differences were not striking, or marked. The erythema came on sooner in the upper field, and was sharper, but there was no desquamation in either.

As Mrs. Quimby has shown, increased depth dose for depths less than 5 cm. is insignificant. The average depth below the posterior skin surface of the centers of the vertebral bodies treated was estimated at 6 cm. She states there is little advantage in a distance greater than 10–12 times the tumor depth. The multiple here would be 60–72 cm. This case therefore verifies the physical conclusions that the long distance technique is of little value at the lesser depths. I also feel that it is not worth while, if you are only going to 2,000 r total per field, because 2,000 r will not injure the skin much anyway in these fractions, at any reasonable range of intensity or distance.

The stumbling block to this type of technique is the economic factor. But those of us who value it may also console ourselves by recognizing that its indications are otherwise limited. I would reiterate these as: malignancy; radioresistant tumors; parts requiring maximum depth; where high total r required. Not worth while up to 2,000 r if given in such fractions as here illustrated.

Mrs. Quimby (closing). I want to express my appreciation for Dr. McIntosh's taking the time and trouble to attempt a clinical verification of the facts I presented. Her experiment is, of course, not completely satisfactory because she did not vary the filter and distance independently. What she has actually done is a study of change of intensity. Nevertheless, we do feel that, to a certain extent, she has shown clinical findings in agreement with the physical prophecies.

# COMPARATIVE CLINICAL VALUE OF SUPER-VOLTAGE ROENTGEN THERAPY*

## WITH CASE REPORTS

*By* T. LEUCUTIA, M.D.
DETROIT, MICHIGAN

NEARLY five years have now elapsed since the first attempts were made to enrich the roentgen therapeutic armamentarium with apparatus operating at voltages higher than the customary 200 kv. The first part of this time was naturally taken up with the development of new engineering ideas and the coordination of the physical measurements. For the last three years, however, a sufficiently accurate control of operation was obtained so that the clinical application of the so-called supervoltage roentgen therapy could be carried out in a routine manner with complete safety to the patient. It remains now to analyze the results obtained to determine whether or not the use of such extremely high voltages, with all the intricacies of generation and energization, is also justified from the practical standpoint.

In considering the physical and biological aspects of the problem there are at least 3 reasons—as has been shown elsewhere[1,2]—why supervoltage roentgen therapy may be assumed to have a greater advantage in certain instances over deep roentgen therapy with 200 kv.: First, there is an increase in the differential action of the roentgen rays with increasing voltage. It is our impression from definite data gained from some experimental work, that this differential action is the result of better absorption conditions and of more efficient scattering effect inherent in the greater penetration of the rays at higher voltages. But regardless of whether the action is an indirect one or is directly dependent on the differential function of the wave length—and this leads us to the second point—there can be no doubt that a proportionately larger dose of radiation can be administered with increasing voltages. Lauritsen,[3,4] by converting the "r" into the "erg" unit of energy and by making use of certain practical observations concerning the number of ergs absorbed per 1 cm.$^2$ of skin to produce an erythema, which he then applied to water as the absorbing medium, calculated a curve of the total number of roentgens required to cause a certain biological effect, as, for example, an erythema for the various voltage ranges up to 2,200 kv. This curve has now been verified in practice as high as 900 kv., and it may therefore be accepted as reflecting truly the proportionate increase in the amount of radiation which can be administered with increasing voltages. To take one single example which refers directly to our problem: if, for instance, a dose of 600 r produces an erythema at 200 kv. (peak), at 600 kv. (constant) a dose of nearly double that amount can be administered to produce the same degree of erythema. Third, the percentage depth dose shows, in addition to certain other deviations from the old isodose curves as plotted for the 200 kv. radiation, an appreciable and proportionate increase with increasing voltages. The summation of these three effects, due to more suitable absorption situations, is noted to still greater advantage in the deeper locations of the body, with the result that a correspondingly larger and a more homogeneous energy can be delivered with increasing voltages to a deep-seated tumor, there being at the same time less injury to the skin and overlying tissues.

Obviously, it will remain for time to furnish the unbiased proof that improve-

* From the Department of Roentgenology, Harper Hospital, Detroit. Read at the Thirty-sixth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 24–27, 1935.

ment in the above physical and biological criteria is followed by a similar improvement in the clinical effect. Comprehensive comparative statistics, dealing with five year cures in the treatment of cancer, will be necessary to establish irrefutable evidence in this respect. But until then we may undertake the rather bold and not altogether too academic step to point to certain arbitrarily chosen lesions, mostly cancerous in nature, which on the basis of past experience with 200 kv. have been noted to respond more readily to the supervoltage technique. In considering such lesions, it appears best to proceed along the line of anatomic distribution or location of the pathologic process rather than to follow the scale of radiosensitivity of the tumor elements composing it, for it appears that the basic laws governing the radiation response remains essentially unchanged. Such a procedure also has the advantage that the problem resolves itself from the practical standpoint into one of technical application.

(1) *Superficial Lesions.* In this group we include cutaneous cancers or other malignant tumors of the skin and those neoplasms which originate or lie underneath the skin near the surface of the body. The technique of the radiation therapy of cutaneous cancers and other malignant tumors of the skin, as, for example, melanosarcoma, etc., is now fairly well established. It appears that the administration of heavy doses of roentgen rays of rather low voltage—whether used alone or in conjunction with other accessory methods (excision, electrocoagulation, curettage, etc.)—constitutes the method of choice. It has been our custom for the past twelve years at Harper Hospital to make use of the so-called "hypermassive" method[5,6] whenever the lesion is not too large at the base or too elevated above the surface. This method consists in the delivery of 4–5 skin unit doses over the malignant process, by including 1 cm. of normal skin around it, with roentgen rays obtained with 85–125 kv. (peak) and no filter. When the lesion is larger than 5 cm. in diameter and rises for 2 cm. or more above the surface of the skin, the "mixed irradiation" with two types of roentgen rays is applied. This consists in the administration of 1 S.U.D. of more penetrating roentgen rays with 200 kv., 1 mm. Cu plus 1 mm. Al as filters first, and then 2–3 S.U.D. of unfiltered rays of low penetration as used in the "hypermassive" method. There is, however, a certain —fortunately, rather small—number of skin malignancies which even with the "mixed irradiation" with the two types of roentgen rays will receive inadequate treatment, and a temporary suppression of the process is all that is brought about. This we observe in lesions which are of a fungating type, rising above the surface for 3 cm. or more, and in the invasive, squamous cell cancers which often penetrate deep into the underlying tissues, producing not infrequently secondary infection especially around bone structure. In such instances, roentgen irradiation with the methods used hitherto will fail to completely destroy the malignant cells of the deeper strata which are the most important from the point of view of cancerous activity, and a temporary restraint of the growth is all that may be expected. The introduction of supervoltage roentgen rays in the "mixed irradiation" is here of decided benefit. The technique which we have evolved during the last three years in this respect is as follows: 1 S.U.D. (1,200 r with back-scattering) is administered with 500 kv. (constant), 7 mm. steel plus 3 mm. Al plus 2 mm. celluloid as filters, over the entire lesion and a large area surrounding it, then 1 S.U.D. (600 r with back-scattering) is given with 200 kv. (peak), 1 mm. Cu plus 1 mm. Al as filters, limited to the site of the lesion proper, and finally 2–3 S.U.D. (1 S.U.D. = 300 r with back-scattering) with 85 kv. (peak), no filter, is delivered through a lead window only to the thicker or more infiltrating point of the lesion, being careful here to protect the normal structures. The entire irradiation is carried out in one single sitting. The

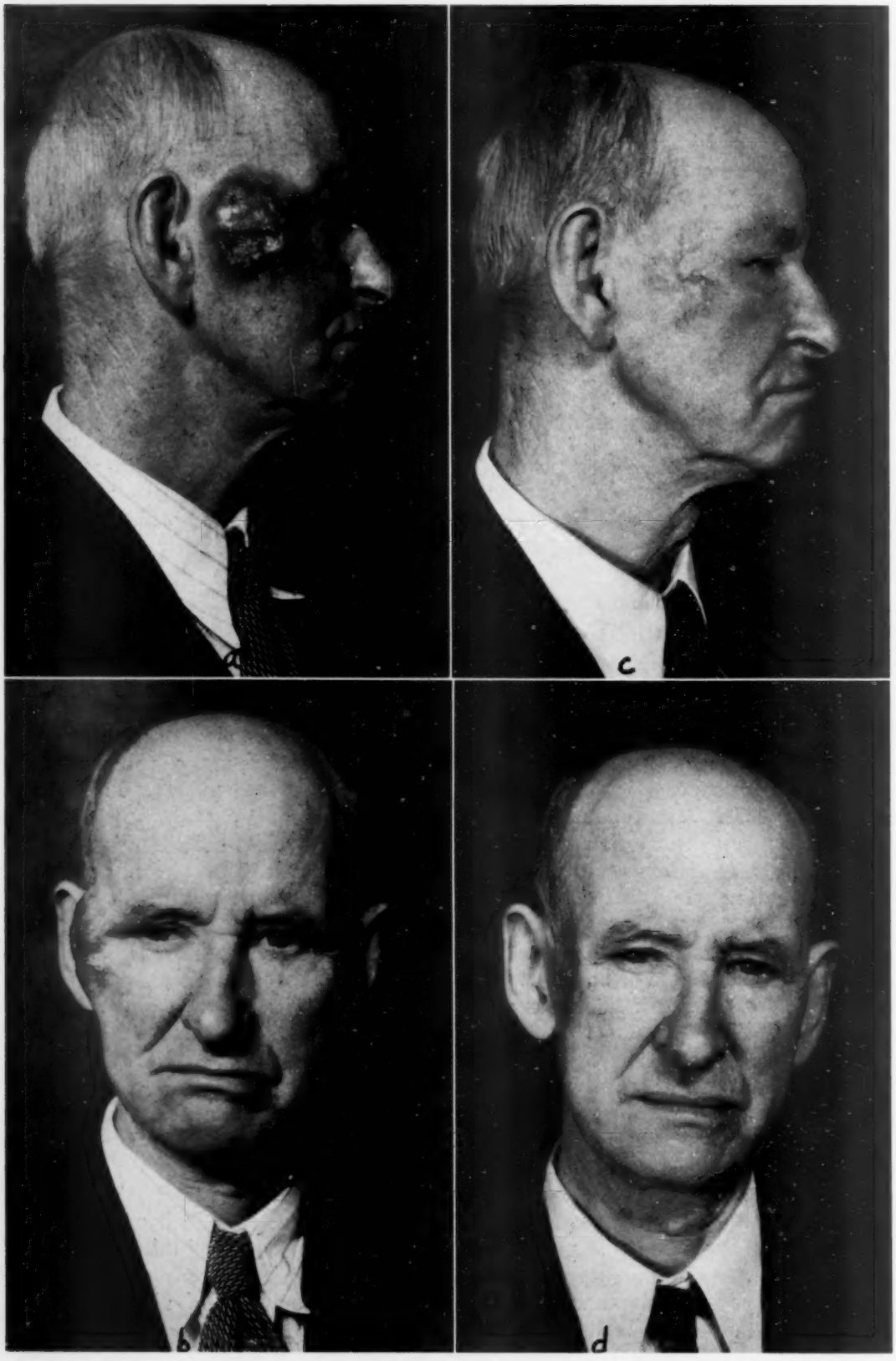


FIG. 1. Case 1. Advanced carcinoma of zygomatic region: *a*, *b*, before and *c*, *d*, after treatment.

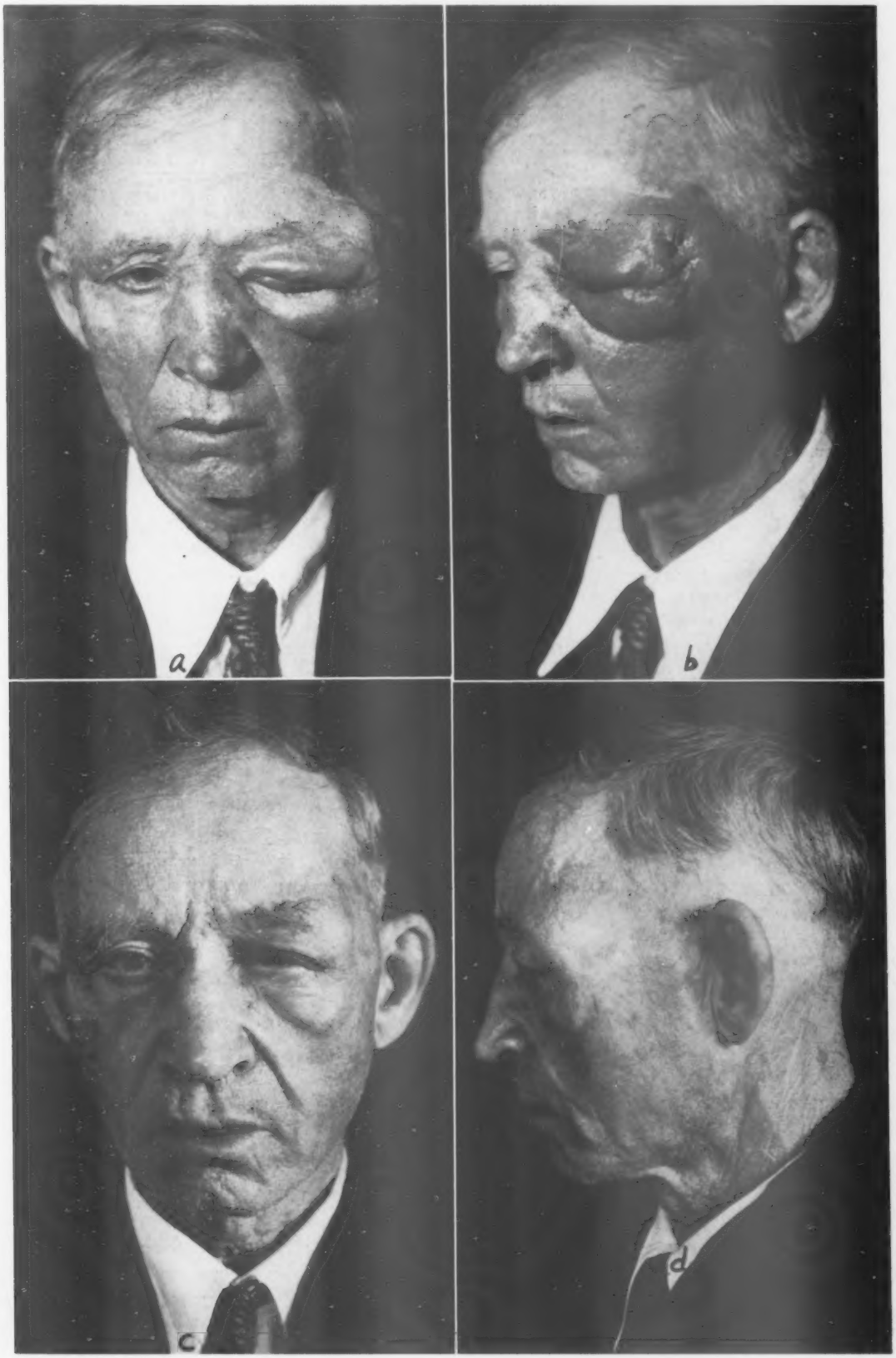


Fig. 2. Case 11. Advanced carcinoma of the left orbit: *a*, *b*, before and *c*, *d*, after treatment.

reaction which develops is rather severe, but since it remains localized to the area exposed is in no way damaging to the repair processes. Within eight to ten weeks, complete healing takes place, as a rule, with very satisfactory cosmetic results.

CASE I. J. W., male, aged sixty-five. Eight years ago the patient first noticed a small, ulcerating, wart-like lesion of the right cheek. This grew progressively larger, but produced no symptoms.

*Findings January 23, 1934.* There was an elevated carcinomatous lesion of the right zygomatic region, extending from the outer border of the orbit nearly to the ear, measuring 7 cm. in the horizontal and 6 cm. in the vertical diameter. The elevation in the midportion was about 3 cm. There were several small ulcerations, with some pus oozing from the deeper structures, indicating secondary infection. (Fig. 1, *a* and *b*). There was no enlargement of the regional lymph glands. The general condition of the patient was uninfluenced by the lesion.

*Treatment.* On January 23, 1934, irradiation with mixed (three types) roentgen rays was given directly over the lesion in one seance:

1 S.U.D. = 450 kv. (constant), 7 mm. steel + 2 mm. Al + 2 mm. celluloid as filters, field 10×10 cm., 60 cm. skin target distance, rate 20 r/min.; dose: 1,100 r (with back-scattering).

1 S.U.D. = 200 kv. (peak), 1.5 mm. Cu + 1 mm. Al as filters, field reduced to 6.5×7.5 cm., 45 cm. skin target distance, rate 20 r/min.; dose: 600 r (with back-scattering).

2 S.U.D. = 85 kv. (peak), no filter, field 6×7 cm., 28 cm. skin target distance, 5 ma., 8 min.

Total dose: 4 S.U.D.

April 20, 1934. Lesion healed.

July 30, 1935. Lesion healed (Fig. 1, *c* and *d*).

CASE II. W. T., male, aged sixty-nine. About eight years ago the patient first noticed a small, pimple-like lesion of the left temple. This increased slowly but steadily in size. One year ago the lesion was excised by a local physician. The healing was not complete, however, and there was prompt recurrence with steady growth.

*Findings June 15, 1935.* There was a very large carcinoma of the left temple, measuring 6.5×7.5 cm. in diameter at the base and of at least 4 cm. elevation. There was central ulceration with a purulent discharge through several sinuses which seemed to penetrate into the carcinoma in a honeycomb manner. There was secondary edema of the left eye with complete closure (Fig. 2, *a* and *b*). There was no enlargement of the regional lymph glands.

*Treatment.* On June 15, 1935, irradiation with mixed (three types) of roentgen rays was given directly over the lesion in one seance:

1 S.U.D. = 500 kv. (constant), 7 mm. steel + 2 mm. Al + 2 mm. celluloid as filters, field 10×12 cm., 60 cm. skin target distance, rate 20 r/min.; dose: 1,200 r (with back-scattering).

1 S.U.D. = 200 kv. (peak), 1.5 mm. Cu + 1 mm. Al as filters, field reduced to 7×8 cm., 45 cm. skin target distance, rate 20 r/min.; dose 600 r (with back-scattering).

2 S.U.D. = 120 kv. (peak), no filter, field 6.5×7.5 cm., 28 cm. skin target distance, 5 ma., 8 min.

Total dose: 4 S.U.D.

August 5, 1935. Lesion healed (Fig. 2, *c* and *d*).

Another field in this group is represented by the malignant lesions which are just underneath the skin (neurogenic sarcoma, spindle cell sarcoma, etc.), or in structures very near the surface of the body (metastases to cervical, supraclavicular, infraclavicular glands, etc.) where crossfiring is very difficult. Supervoltage roentgen therapy, because of the more uniform and larger distribution of the radiation in the first 2 or 3 cm. layers beneath the surface and because of the greater tolerance of the skin, will often lead to better results with one single field than 200 kv. deep roentgen therapy with the crossfiring method.

(2) *Lesions about the Face and Neck.* There is hardly any location of the human body which offers a medium as complex and unsuitable for homogeneous irradiation as the face and neck. The presence of the air-containing oral and upper respiratory cavities with all the numerous accessory fossae and sinuses, the sharp angulation of many of the bones, the very irregular anatomic construction and, in many instances, distribution of the teeth, the great variation from individual to individual of the contour of the nose, chin and neck, and finally the great radiosensitivity of some of the structures contained therein,

as, for example, the cartilage of the septum of the nose, or still worse, of the larynx, etc., constitute factors which render the volume to be irradiated so variant in conformation and heterogenous in density that the exact calculation of any depth dose becomes an impossibility. This great physical difficulty has been reflected in no uncertain manner in the clinical results in the roentgen therapy with 200 kv. of all lesions located about the face and neck. To take one example: It is fairly well agreed that metastatic carcinomas to the submental, submaxillary or even cervical glands are quite resistant to radiation, whereas the same type of carcinoma in other locations, as, for instance, in the axilla, may entirely disappear following irradiation. For this same reason, the local application of radium, either in the form of interstitial puncture or tubes or surface applicators has been brought more and more to the foreground in the treatment of most lesions of the nasal, oral, pharyngeal and laryngeal cavities, external irradiation with roentgen rays being reserved merely as an accessory method. If the lesion appeared more extensive than could be covered with radium, palliation was as a rule all that could be offered. Realizing these great difficulties, some years ago Coutard evolved the method which now bears his name and which has produced some improvement in the technique of roentgen irradiation with 200 kv., rendering it more amenable and decidedly more efficacious. It is our impression, however, that supervoltage roentgen therapy constitutes a still more definite step forward. Not only do we obtain a better homogeneity within the irradiated volume, but at the same time we can administer an appreciably larger dose with less injury to the highly sensitive structures, as, for example, the cartilage of the larynx. In a few instances, we have combined the use of two types of roentgen rays (obtained with 200 kv. peak and 500 kv. constant respectively) and it is our opinion that this method of "mixed irradiation" deserves very earnest consideration. It appears that because of the great variation in the density of the structures, some of the tissue elements will be affected to greater advantage with the one type and others with the other type of radiation.

Case III. J. R., male, aged forty-eight. Nine months ago, the patient noticed a swelling of the glands of the neck immediately under the chin, which was attributed to the pathologic condition of the lower right first molar. Extraction of the tooth, however, failed to influence the swelling of the submental glands. A few weeks later, there was beginning enlargement of the glands in the right submaxillary and cervical regions, which was persistent and progressive. A biopsy of one of the enlarged submental glands was made on August 28, 1933, and the microscopic findings were those of a diffuse metastatic carcinoma of the lymph node, primary lesion not determined.

*Findings September 5, 1933.* There was evidence of enlarged lymph nodes in the submental region from 1 to 2 cm. in diameter and enlargement of the cervical glands on the right side 1 to 4 cm. The wound from the recent incision had a discharging sinus in the center. There was no evidence of a primary lesion in the oral cavity.

*Treatment.* Irradiation was directed to the submental, submaxillary and cervical regions with supervoltage roentgen therapy.

*First series:* September 7–14, 1933, two portals, one from each side of the neck, 400 kv. (constant), 7 mm. steel+2 mm. Al+2 mm. celluloid as filters, field 15×20 cm., 60 cm. skin target distance, rate 20 r/min., four fractions alternately over the two sides of the neck of 400 r (with back-scattering) each. Total dose, 1½ S.U.D. over each field during a period of eight days.

*Second series:* October 23–28, 1933, technique the same, but only three fractions of 300 r each were administered. Total dose: 1 S.U.D. over each field during a period of six days.

August 30, 1935. Lesion healed. There is some leathery appearance of the skin.

Case IV. Mrs. A. S., aged seventy-two. Patient stated that in April, 1933, she noticed some tenderness of the right side of the mouth, so that for the past two months she had taken little solid food. The patient had worn a full denture for the past twenty years.

*Findings September 20, 1933.* At this time

FIG. 3. Case v. Advanced carcinoma of the left nostril, maxilla and lower orbit with metastases to the glands of the neck, *a*, before, and *b* after treatment.

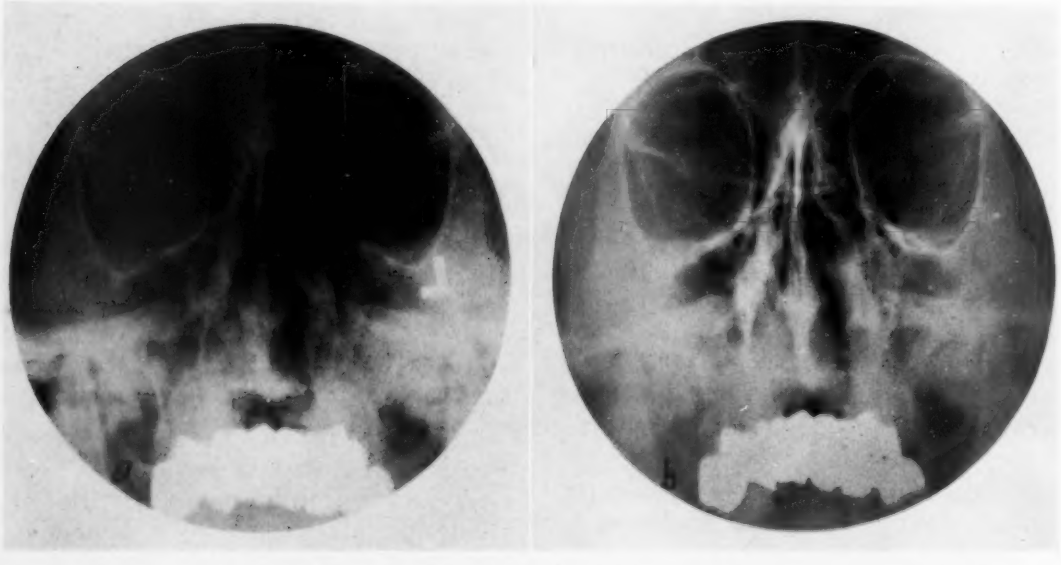

FIG. 4. Case v. *a*, shows the destructive process of the left antrum and especially of the adjacent part of the orbit; *b* shows complete regeneration of bone with some added sclerosis of the left antrum.

there was evidence of a lesion filling the gingivobuccal space of the right lower jaw in the region of the anterior incisors and extending back as far as the molars. In the region of the canine, the lesion was ulcerated and some pus could be pressed out. Roentgen examination of the mandible revealed some destruction of the bone of the alveolar process in this region.There was marked enlargement of the submaxillary and upper cervical lymph nodes from 1 to 3 cm. in diameter on the right side, producing disfigurement of the contour of the neck. A biopsy from the site of the primary lesion revealed squamous cell carcinoma.

*Treatment.* Irradiation was directed to the lower face and entire neck.

*First series:* September 20 to October 10, 1933, fractionated protracted irradiation with mixed (two types) roentgen rays was given. The one type was obtained with 400 kv. (constant), 7 mm. steel+2 mm. Al+2 mm. celluloid as filters, 1 s.u.d.=900 r (with back-scattering), and the other with 200 kv. (peak), 1.5 mm. Cu+1 mm. Al as filters, 1 s.u.d.=600 r (with back-scattering), two lateral fields of 15×25 cm. each, 60 cm. skin target distance, rate 20 r/min., fractions of $\frac{1}{5}$ s.u.d. alternately over each field daily and changing the type of rays every third day. Total dose: 2 s.u.d. over each field within a period of twenty days.

*Second series:* November 20–25, 1933, irradiation with supervoltage roentgen therapy alone, same technique, but only three fractions of $\frac{1}{4}$ s.u.d. over each field. Total dose: $\frac{3}{4}$ s.u.d. on each side over a period of six days.

*Third series:* January 29, 1934, to February 10, 1934, same technique as in second series, but the fields were smaller and the radiation was directed chiefly to the mental region, six fractions of $\frac{1}{5}$ s.u.d. over each field. Total dose: $1\frac{1}{5}$ s.u.d. on each side over a period of twelve days.

July 30, 1935. Lesion entirely healed. Practically normal skin of face and neck.

Case v. W. H. W., male, aged forty-six. Six months previously, the patient first noticed that the left nostril had become completely blocked. For the past three months he had had marked epistaxis and marked discharge from the left nostril. About one week ago, he developed double vision. At this time, a small piece of the nasal tumor was removed for biopsy the microscopic findings being those of a medullary carcinoma.

*Findings October 13, 1933.* There was evidence of a fungating tumor mass filling the entire nasal cavity. Roentgen examination of the nasal accessory sinuses revealed that this mass also filled the entire left antrum, destroying most of the bone and displacing the septum toward the opposite side. The tumor extended upward into the left orbit, pushing the left eye upward and laterally (Figs. 3*a* and 4*a*). There was clouding of the opposite antrum as well as of the left frontal sinus, due, no doubt, to secondary edema. The tumor also extended down into the pharynx.

There was enlargement of the lymph nodes of both sides of the neck from 1 to 5 cm. on the left and from 1 to 3 cm. on the right, these no doubt representing metastases.

The patient was quite emaciated and very anemic.

*Treatment.* Irradiation included the entire head and neck through two lateral fields.

*First series:* October 16–21, 1933, 450 kv. (constant), 7 mm. steel+2 mm. Al+2 mm. celluloid as filters, fields 20×30 cm., 60 cm. skin target distance, rate 20 r/min., three fractions of 40 per cent s.u.d. (400 r with back-scattering) over each field alternately. Total dose: 120 per cent s.u.d. on each side over a period of six days.

*Second series:* January 15–20, 1934, technique identical with first series.

*Third series:* April 16–21, 1934, same technique.

August 1, 1935. Complete healing (Figs. 3*b* and 4*b*).

(3) *Intrathoracic Lesions.* Another group in which radiation therapy with 200 kv. is most difficult is represented by the tumors situated within the thoracic cage. On the one hand is the necessity of using in the process of crossfiring large fields so as to be able to administer the required dose at the site of the tumor, and on the other hand, there is the exceedingly great danger of producing tissue changes in the normal lung which, because of the vital importance of this organ, may lead to serious functional impairment or even death. It was shown in former publications[7,8] that the administration in one series of a dose larger than 130 per cent s.u.d. invariably results in pneumonitis fol-

lowed by some fibrosis, whereas if the treatment is repeated for two or three series, a complete fibrosis of the irradiated lung develops. In massive tumors of the mediastinum or neoplasms around the roots of the lungs, which comprise the majority of the bronchogenic carcinomas, this constituted a very serious handicap for, by using several large fields for the purpose of crossfiring, so much of the normal lung tissue had to be included in the field of irradiation that a serious damage could not be prevented. As a rule, no other alternative remained than to limit the number and size of the fields of entry and thus generally reduce the dose, a fact which by force of circumstance always led to under-treatment of the irradiated tumor. The futility of such a procedure was plainly evidenced in the clinical results. Only a few of the highly radiosensitive mediastinal lymphosarcomas or thymomas could be made to disappear permanently, whereas in the other types of mediastinal tumors a temporary regression was all that could be hoped for. As for bronchogenic carcinomas, there are only exceptional cases on record which seemed to be controlled by irradiation. The introduction of supervoltage roentgen therapy in this field has two distinct advantages: (1) it permits, because of its greater depth dose, the irradiation of the mediastinum or roots of the lungs directly through a more limited volume (usually one anterior and one posterior field, or one anterior and two posterior or one posterior and two anterior fields), this helping to prevent severe pneumonitis or fibrosis even in cases in which treatment has to be repeated with large doses for several series, and (2) in the cases in which fibrosis is desired, it permits the induction of such a process by the use of several smaller fields crossfiring a rather limited area, whereas formerly because of the large portals which had to be employed to obtain the necessary depth dose the fibrosis had to be extended to a large part of the lung or even to the entire one-half of the chest.

CASE VI. J. R., male, aged eleven. In the fall of 1931 the patient sustained a fractured nose, with widely dislocated and deviated nasal septum which resulted in difficulty in breathing. Following healing of the fracture, however, the difficulty in breathing persisted and grew progressively worse, later being associated with considerable cough. Roentgen films of the chest in December, 1931, showed three well-defined, sharply circumscribed, rounded shadows at the root of the right lung indicating enlarged mediastinal glands. One of the shadows was at least 5 cm. in diameter (Fig. 5*a*). The long bones and the skull were examined roentgenologically, but they appeared entirely normal.

Since no accurate diagnosis could be made, the patient was referred to our department for the administration of a therapeutic test dose of roentgen rays over the chest.

*Findings December 8, 1931.* The patient was rather poorly developed for his age, undernourished, very nervous and uncontrollable. There was no enlargement of any of the palpable lymph nodes and no enlargement of the liver or spleen. Blood count: Hb, 84 per cent; red blood cells, 4,520,000; white blood cells, 16,960; polymorphonuclears, 79 per cent; lymphocytes, 7 per cent; mononuclears, 14 per cent. Temperature normal.

*Treatment:* Irradiation was directed over the mediastinum with deep roentgen therapy.

*First series:* December 8–9, 1931, 200 kv., 1 mm. Cu+1 mm. Al as filters, one anterior and one posterior field of 15×20 cm., 60 cm. skin target distance, rate 20 r/min., 1 S.U.D. =600 r (with back-scattering) over each field.

There was a very prompt disappearance of the enlargement of the mediastinal glands (Fig. 5*b*), this making the diagnosis of lymphosarcoma probable. Two months later, therefore, the radiation therapy was extended to the entire abdomen and pelvis to forestall metastases.

The patient remained entirely well until January, 1935, when during the periodical checkup examination a recurrence of the mediastinal process was noted (Fig. 5*c*). To obviate fibrosis of the lung by the use of large fields with 200 kv., it was decided at this time to apply supervoltage roentgen therapy with smaller fields limited to the mediastinum proper.

*Second series:* January 11–15, 1935, 500 kv. (constant), 7 mm. steel+2 mm. Al+2 mm. celluloid, one field over mediastinum anteriorly and one posteriorly of 10×12 cm. each, 60 cm. skin target distance, rate 20 r/min., two frac-

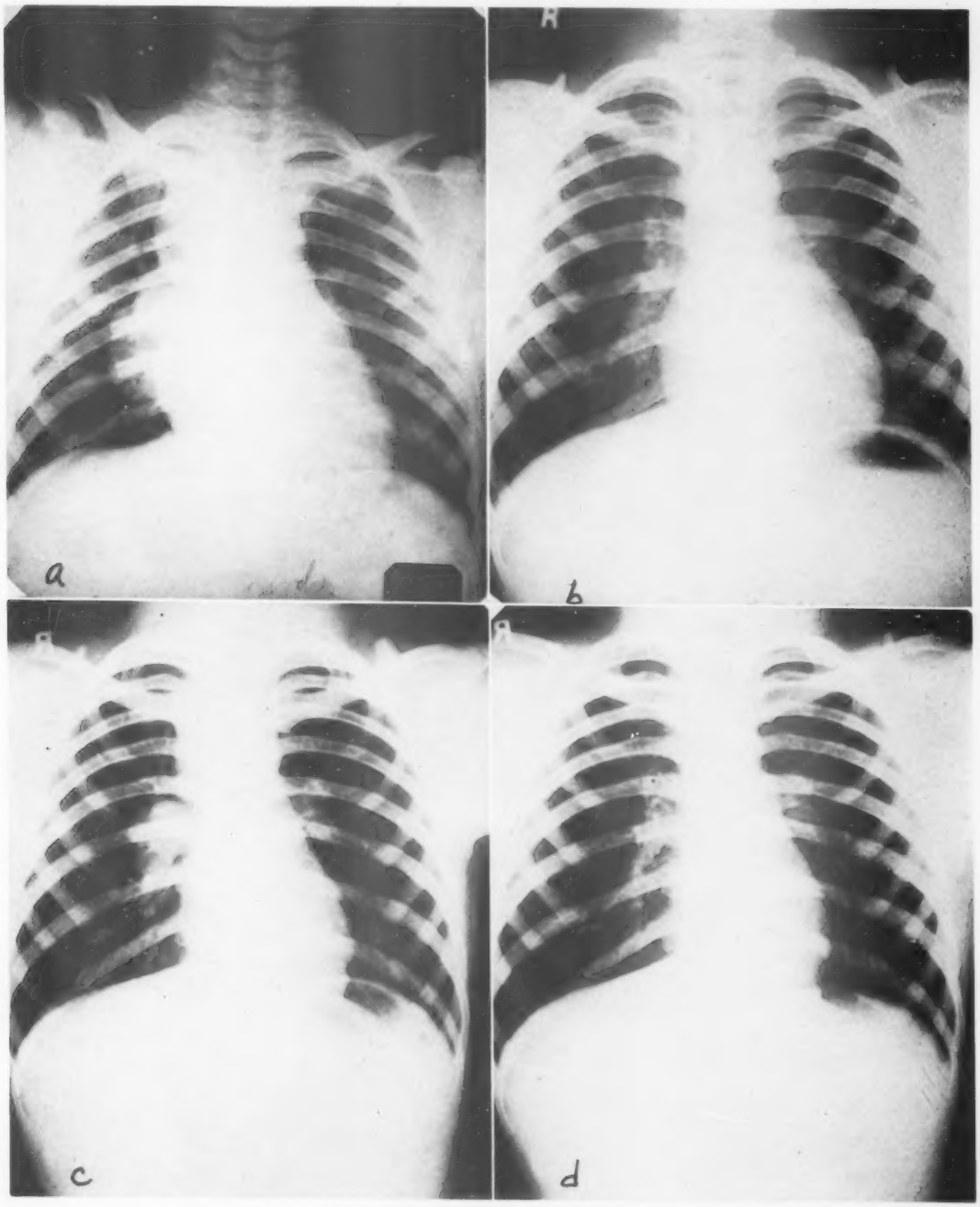


Fig. 5. Case vi. *a*, lymphosarcoma, of mediastinum in 1931; *b*, same after deep roentgen therapy; *c*, recurrence in 1935; *d*, same after supervoltage roentgen therapy with small fields. No fibrosis.

tions of 30 per cent s.u.d. (350 r with back-scattering) over each field. Total dose: 60 per cent s.u.d. on each field over four days.

July 30, 1935. The chest showed a normal appearance (Fig. 5*d*). General condition good.

Case vii. J. J., male, aged forty-one. In August, 1934, the patient noticed some pain in upper chest, which was associated with a choking sensation. Soon after, a progressive swelling of both sides of the neck as well as of the entire right upper extremity developed. Within the past month, there was a dry, hacking cough with marked difficulty in breathing.

*Findings October 9, 1934.* Patient was well

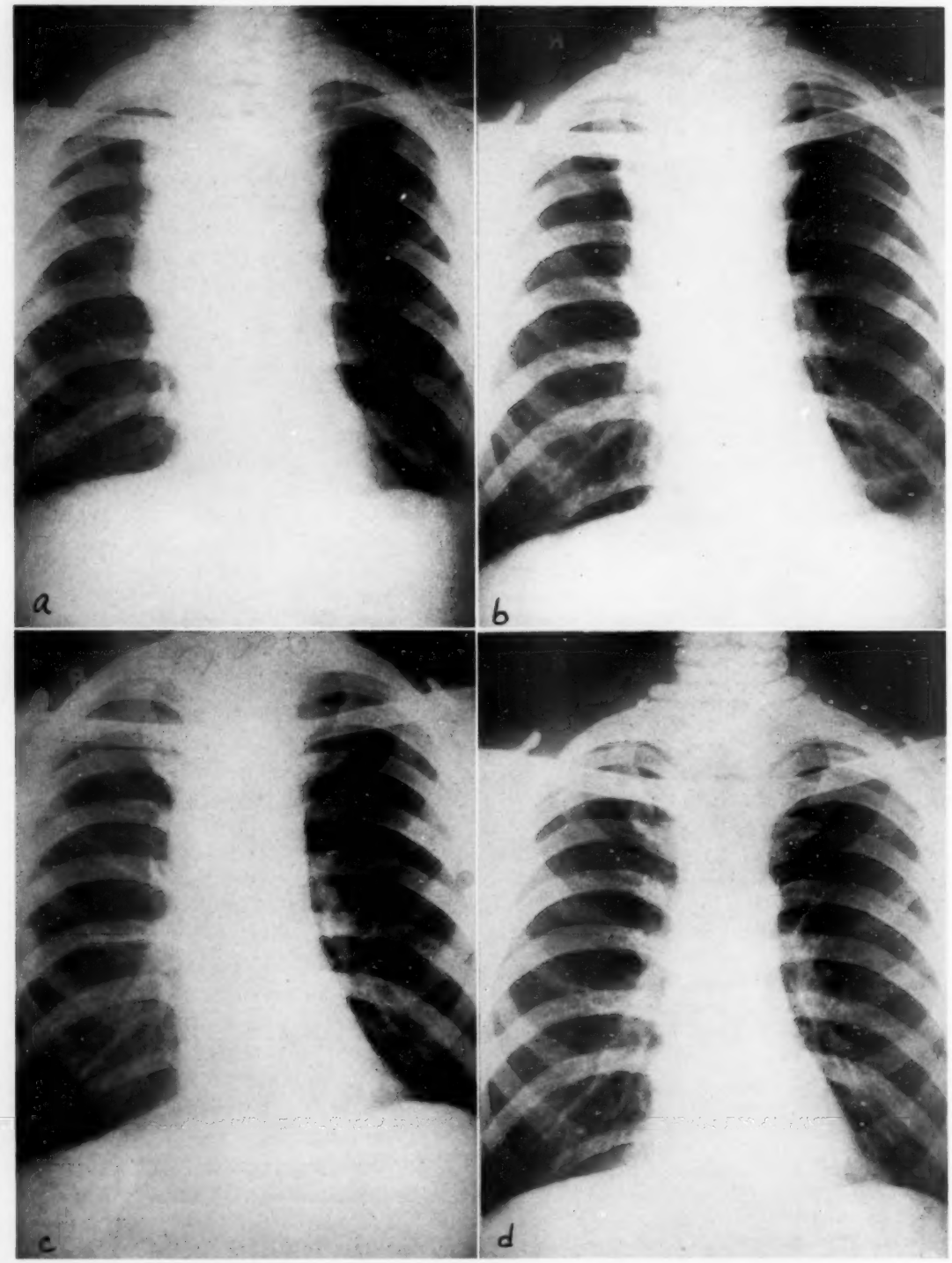


FIG. 6. Case VII. *a*, mediastinal sarcoma; *b*, same after first series of supervoltage roentgen therapy; *c*, same one month after second series of supervoltage roentgen therapy; *d*, same one year later. No fibrosis.

developed, of robust constitution, showing considerable dyspnea. There was very marked swelling of the entire right upper extremity. There was marked edema of the subcutaneous tissues of the neck, such as is observed in mediastinal tumor, with marked dilatation of all the superficial veins of the anterior thoracic wall.

Roentgen examination of the chest revealed a tumor mass involving the mediastinum and the supracardiac region as well as the glands in both hila. Roentgenoscopically the mass did not pulsate with the aorta. The appearance was that of a mediastinal neoplasm (Fig. 6*a*).

*Treatment.* Irradiation of the mediastinum and later of the abdomen, pelvis and entire lymphatic system.

*First series:* October 12–19, 1934, 500 kv. (constant), 7 mm. steel+2 mm. Al+2 mm. celluloid, two fields, one over mediastinum anteriorly and one posteriorly, of 15×25 cm. each, 60 cm. skin target distance, rate 20 r/min., three fractions of 40 per cent S.U.D. (450 r with back-scattering) over each field. Total dose: 120 per cent S.U.D. on each field during six days. Because of the extreme dyspnea, oxygen inhalation had to be administered during the entire course of the treatment.

Examination of the chest on November 21, 1934, revealed that the mediastinal tumor was reduced to about one-half of the original size (Fig. 6*b*), a fact which would tend to rule out lymphosarcoma and make the diagnosis of spindle cell sarcoma or fibrosarcoma more probable.

*Second series:* November 21–30, 1934. This consisted of two parts: from November 21 to 26, deep roentgen therapy with 200 kv. was given by employing the routine technique over the pre-, postauricular, submental, submaxillary, supra-, infraclavicular and axillary lymph nodes, over the entire abdomen and over the pelvis, including all of the inguinal and femoral lymph nodes. A dose of about 100 per cent S.U.D. was administered throughout each field or area. From November 27 to 30, the supervoltage roentgen therapy was repeated over the mediastinum. The technique was the same as for the first series except for the fact that only two fractions of 40 per cent S.U.D. were given over each field.

July 30, 1935. Chest shows normal appearance without the slightest trace of fibrosis (Fig. 6*d*). General condition of the patient excellent.

Case VIII. F. A., female, aged thirty-eight. The patient stated that since 1926 she had had some cough with moderate expectoration. Repeated roentgen examinations revealed the presence of a bronchiectasis, but nothing was done in the way of treatment. In April, 1934, the cough became more marked and there was increase in the amount of expectoration. Bronchoscopic examination was made on June 15, 1934, which revealed on the right side, about 1 cm. distal to the carina, a localized inflamed area of the mucous membrane which had the appearance of early carcinoma, and a biopsy was taken. Microscopic examination, however, revealed no positive evidence of malignancy. On June 20 lipiodol was introduced for diagnostic purposes. Stereoscopic films of the chest revealed a moderate bronchiectatic change at the left base, with cylindrical dilatation of the bronchi. On the right side and well posterior in the chest there was a cavity in the lung tissue measuring $1\frac{3}{4}\times 2$ inches, which filled readily with the opaque oil (Fig. 7*a*). On June 22, bronchoscopy was repeated. The area in the right main bronchus appeared the same as at the previous examination. A biopsy was again taken. The microscopic findings at this time were those of cylindrical cell carcinoma of the bronchus. A phrenicectomy, removing 16 cm., was performed on June 22.

*Findings June 29, 1934.* The patient was well developed, well nourished, weighing over 150 lb. There was no loss of weight. The physical examination was practically negative except for the pulmonary findings. There was no adenopathy.

*Treatment.* External irradiation with supervoltage roentgen therapy and intrabronchial application of radium.

*First series:* June 29 to July 7, 1934. The supervoltage roentgen therapy was carried out with 500 kv. (constant), 7 mm. steel+2 mm. Al+2 mm. celluloid as filters, two fields of entry, one over the mediastinum and right lung root anteriorly and one posteriorly, of 15×25 cm. each, 60 cm. skin target distance, rate 20 r/min., three fractions of 40 per cent S.U.D. (450 r with back-scattering) over each field. Total dose: 120 per cent S.U.D. on each field during six days.

On the seventh day, 50 mg. radium, screened by 1 mm. brass, without outer filter, was introduced under bronchoscopic-roentgenoscopic control, into the right main bronchus directly opposite the lesion and left in situ for a period of ten hours (500 mg-hr.).

*Second series:* October 30 to November 9, 1934, technique identical with that of the first series, except that the two fields were reduced to 12×18 cm.

July 30, 1935. The patient is in excellent health. Roentgenogram of the chest shows only slight fibrosis of the right lower lung (Fig. 7*b*). The elevation of the diaphragm is due to the phrenicectomy which was done to control the bronchiectasis.

*First series:* June 6–14, 1934. The technique of procedure in this case was identical to that used in Case VIII except for the fact that the dose was 20 per cent larger.

*Second series:* September 28 to October 7, 1934. Identical technique to that used for the first series.

July 30, 1935. The patient is in good general condition. A roentgenogram of the chest shows that the fibrosis in this case is more pronounced

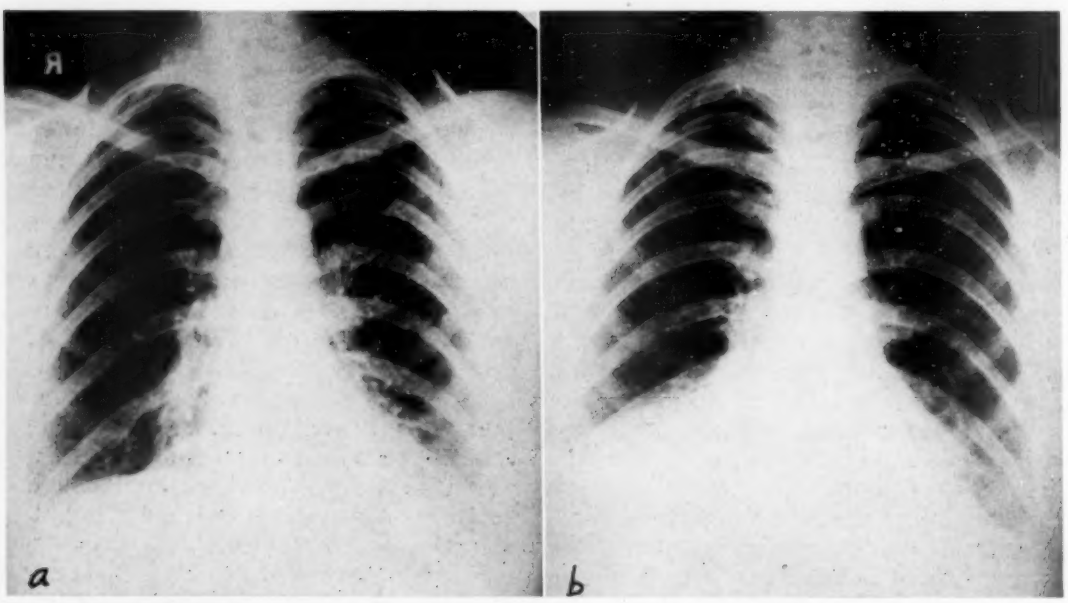


FIG. 7. Case VIII. Cylindrical cell carcinoma of right main bronchus and bronchiectasis of right lower lobe before and after treatment. The elevation of the right leaf of the diaphragm is the result of phrenicectomy.

CASE IX. F. W., female, aged thirty-six. The patient had a dry, hacking cough for only three weeks. Bronchoscopic examination on June 3, 1934, showed a small tumor on the posterior wall of the right main bronchus, a portion of which was removed for biopsy. The microscopic findings were those of cylindrical cell carcinoma. Roentgen examination of the chest showed some infiltration of the right root of the lung and discrete bronchial markings throughout the proximal portion of the right lung field (Fig. 8*a*).

*Findings June 6, 1934.* The patient was well developed, well nourished, weighing about 140 lb. There was very marked difficulty in breathing, with wheezing and shortness of breath.

*Treatment.* External irradiation with supervoltage roentgen therapy and intrabronchial application of radium (Fig. 8, *b* and *c*).

than in Case VIII, due no doubt to the larger dose which was used (Fig. 8*d*).

We may mention at this point also the improved results which are obtained in irradiating by supervoltage roentgen therapy certain cases of inoperable carcinoma of the breast. Here the use of crossfiring by the tangential method not infrequently brings about the complete disappearance of the primary tumor of the breast as well as of the metastatic lymph nodes of the axilla without the slightest injurious effect to the intrathoracic structures.

CASE X. M. G., female, aged sixty-six. In February, 1934, the patient first noticed a lump in the left breast. On April 18, 1934, a biopsy of the tumor was made by electrocautery, the

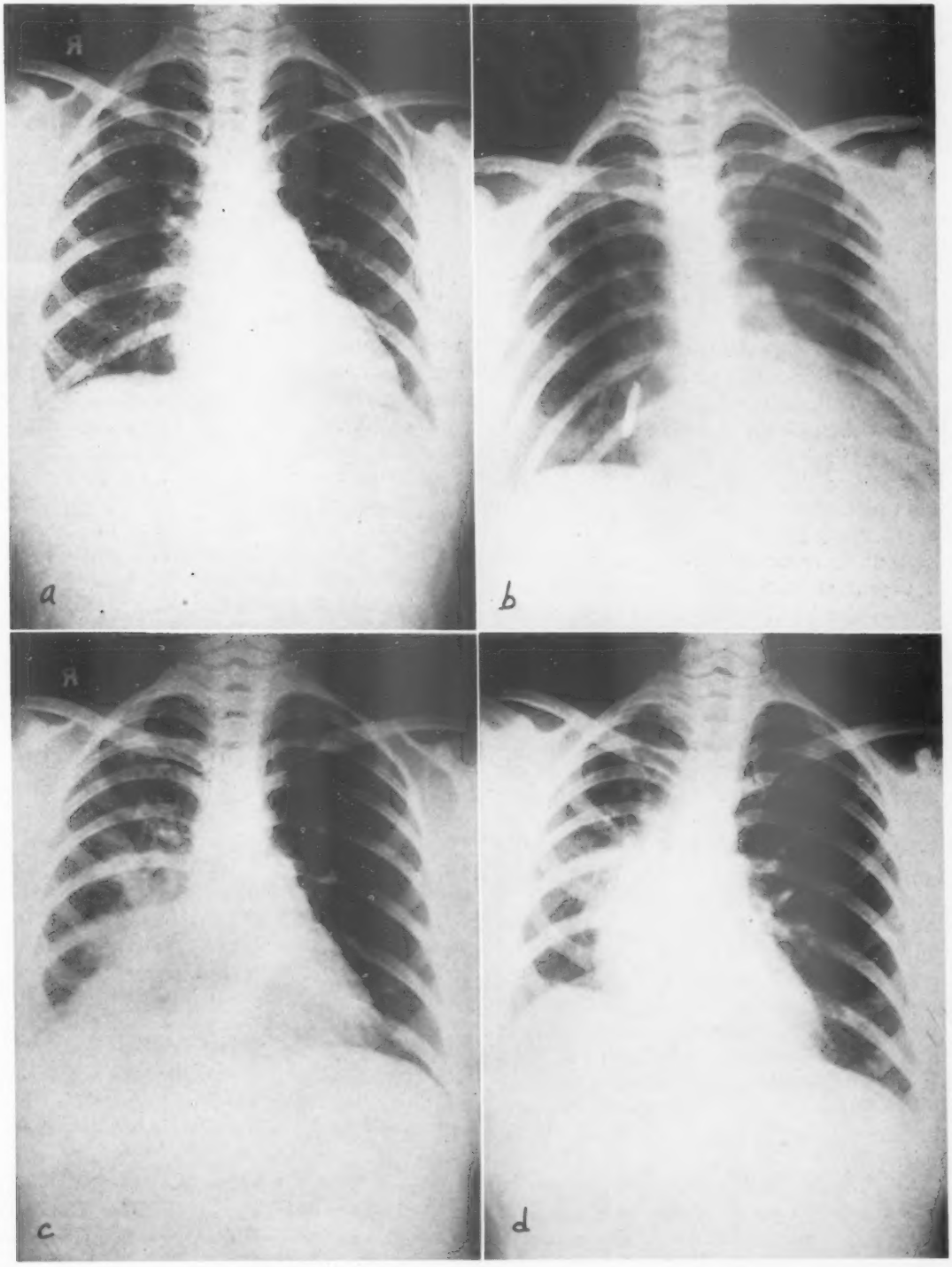


Fig. 8. Case IX. *a*, cylindrical cell carcinoma of right main bronchus; *b*, radium in position; *c*, radiation pneumonitis over localized area; *d*, same, one year later; limited fibrosis.

microscopic report being advanced adenocarcinoma of the duct of the breast. Since the patient suffered from marked hypertension, it was decided to use radiation therapy as the primary procedure.

*Findings April 20, 1934.* There was a small incision in the upper, outer quadrant of the left breast where the biopsy was taken. On palpation, it appeared that the whole upper, outer quadrant of the left breast was invaded by the tumor and there was enlargement of the lymph nodes in the left axilla about 1.5 cm. in diameter. The general condition of the patient was good.

*Treatment.* Tangential irradiation of the left breast and axilla with supervoltage roentgen therapy and direct irradiation of the supra-, infraclavicular and cervical glands with 200 kv. therapy.

*First series:* April 20–24, 1934. The irradiation of the left breast and axilla was carried out with 450 kv. (constant), 7 mm. steel+2 mm. Al+2 mm. celluloid as filters, two tangential fields angulated outward so as to exclude irradiation of the lung, one anteriorly chiefly for the breast and one posteriorly for the axilla, field 15×20 cm., 60 cm. skin target distance, rate 20 r/min., two fractions of 30 per cent S.U.D. (330 r with back-scattering) on each field over a period of four days. At the site of the tumor area of the breast, an additional 40 per cent S.U.D. was given through a small field 6×8×10 cm.

The irradiation of the supra-, infraclavicular and cervical regions was the same as generally practiced with the 200 kv. technique.

*Second series:* May 29 to June 2, 1934. Same technique as for the first series.

*Third series:* July 24–28, 1934. Same technique as for the first series, but the dose was 20 per cent less throughout.

*Fourth series:* February 26 to March 2, 1935. Same technique as for the first series, but the dose was 30 per cent less throughout. The last two series were given merely for prophylactic reasons.

July 30, 1935. Examination entirely negative General condition good. A roentgenogram of the chest shows normal appearance, there being not the slightest trace of fibrosis.

(4) *Pelvic and Abdominal Lesions.* Of the pelvic tumors, the most apparent benefit is obtained in connection with carcinoma of the cervix. One of our first cases treated which showed perhaps the most remarkable result was a woman suffering from a terminal cancer of the cervix with frozen pelvis and vesicovaginal fistula. At the present time, more than two and a half years later, the carcinoma is entirely healed and the fistula closed, the pelvis giving the impression as if a complete hysterectomy had been performed.

CASE XI. F. A., female, aged forty-five. In the fall of 1932, the patient developed a serohemorrhagic vaginal discharge, which later became very abundant and offensive in odor. For about one month or so, the patient noticed that urine was escaping through the vagina.

*Findings May 18, 1933.* The patient was in only fair general condition. The vaginal examination revealed a large, fungating mass occupying the entire cervix and upper vagina, with considerable sphacelation and the presence of a vesicovaginal fistula. The parametria were also invaded and the pelvis had a "frozen" appearance. A small fragment was removed for biopsy, this revealing advanced medullary carcinoma.

*Treatment.* External irradiation with supervoltage roentgen therapy and intrauterine and paracervical application of radium.

*First series:* May 18, 1933, 50 mg. of radium, screened by 1 mm. brass and 1 mm. hard rubber was placed in the lower uterine segment, cervical canal and vaginal fornices by use of suitable containers and left in situ for a period of seventy-two hours (3,600 mg-hr.). From May 14 to 24, supervoltage roentgen therapy was given with 400 kv. (constant), 7 mm. steel +2 mm. Al+2 mm. celluloid as filters, two fields, one over the pelvis posteriorly and one anteriorly, of 20×25 cm., 60 cm. skin target distance, rate 20 r/min., two fractions of 60 per cent S.U.D. (560 r with back-scattering) over each field, the total dose being 120 per cent S.U.D. per field given during a period of four days.

*Second series:* July 10–17, 1933. On this occasion supervoltage roentgen therapy alone was used. The procedure was the same except for the fact that three fractions of 30 per cent S.U.D. were given on each field over a period of eight days.

*Third series:* November 18–22, 1933. The technique of this series was identical to that of the first series, again a combination of super-

voltage roentgen therapy and radium being used.

July 30, 1935. The vaginal examination is entirely negative, the impression on bimanual palpation being that a complete hysterectomy has been performed. The vesicovaginal fistula is closed (now for a period of over one year) and the general condition of the patient is excellent.

The use of supervoltage roentgen therapy in uterine carcinoma has another advantage which is worthy of mention. For the past few years, several cases of completely healed cancer of the uterus have been observed in which a fracture (with non-union) of the neck of one or even both femora occurred due to the osteoporosis brought about through the use of multiple portals of entry for the purpose of crossfiring. Supervoltage roentgen therapy permits the use of external irradiation with a greater economy in fields and volume.

Other deep-seated tumors situated in the pelvis or abdominal cavities in which favorable results have been observed from the supervoltage roentgen therapy include carcinoma of the ovary, rectum, prostate, bladder, etc., but it would extend the scope of this presentation to enter into a detailed discussion of the irradiation of all these conditions. One may say only that the same general biologic criteria expounded in the introductory notes hold true and that the technique of procedure is regulated to conform with those criteria.

## CONCLUSIONS

It appears safe to conclude from the above that the addition of supervoltage roentgen therapy to the treatment armamentarium forms an important step, the value of which grows more evident as statistical results are published. Whereas it cannot be said that the general laws of radiosensitivity, and thus of radiation response to the tumors as a whole, are influenced to any appreciable extent, nevertheless the better distribution and the creation of more advantageous absorption conditions within the tissues irradiated help to bring about an increasing improvement of the therapeutic results. In this respect, supervoltage roentgen therapy in its present form up to 1,000 kv. bridges over the gap which exists between deep roentgen therapy with 200 kv. and the gamma rays of radium. But, as with both of these agents, it will continue to remain of only local effect. Because of its greater magnitude, it will cause more bulky tumors to disappear and it will clear up more extensive local invasions, as, for example, a "frozen" pelvis, but as soon as the malignant process becomes disseminated to distant parts of the body, it will fail to control the disease. Therefore supervoltage roentgen therapy cannot be said to represent more than an additional aid—though a very important one—in the solution of the cancer problem as a whole.*

## REFERENCES


1. Leucutia, T., and Corrigan, K. E. The present status of roentgen therapy with voltages above 200 kv. Am. J. Roentgenol. & Rad. Therapy, 1934, *31*, 628–662.
2. Leucutia, T., and Corrigan, K. E. The problem of uniform distribution of the radiation field in superhigh voltage roentgen therapy with tubes operating on a continuous pump. Am. J. Roentgenol. & Rad. Therapy, 1935, *34*, 664–677.
3. Lauritsen, C. C. Energy considerations in high voltage therapy. Am. J. Roengtenol. & Rad. Therapy, 1933, *30*, 380–387.
4. Lauritsen, C. C. Energy considerations in medium and high voltage therapy. Am. J. Roentgenol. & Rad. Therapy, 1933, *30*, 529–532.
5. Evans, Wm. A., and Leucutia, T. "Massive" and "hypermassive" radiation in the treatment of skin cancer. *Brit. J. Radiol.*, 1928, 1, 396–427.
6. Evans, Wm. A., and Leucutia, T. The treatment of melanotic tumors of the skin; pigmented moles and malignant melanomas. Am. J. Roentgenol. & Rad. Therapy, 1931, *26*, 236–259.
7. Evans, Wm. A., and Leucutia, T. Deep roentgen therapy of neoplastic pulmonary metastases. Am. J. Roentgenol. & Rad. Therapy, 1924, *11*, 35–50.
8. Evans, Wm. A., and Leucutia, T. Intrathoracic changes induced by heavy radiation. Am. J. Roentgenol. & Rad. Therapy, 1925, *13*, 203–220.


* For discussion see page 378.

# A YEAR'S EXPERIENCE WITH 800 KV. ROENTGEN RAYS

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IN MAY, 1934, we began the operation of a roentgen therapy installation at the University of California Hospital at about 800 kv. (peak). It is a resonance transformer consisting of a coil in a large tank, with the anode at the free end of the coil, two oscillator tubes, a pump and a cooling system. There is a good technical description of the apparatus in the *Physical Review* for Jan. 1, 1935, by Dr. David Sloan, who was largely responsible for its construction.

We have had various difficulties with it, and are still having a few, but on the whole it has given satisfactory service. It now runs quite smoothly and continuously at 900 kv. and has been operated for some time at 1,000–1,200 kv. Our physicists have enthusiastic ideas about doubling this voltage but it probably will not be worth while to do so.

The cathode has a negative bias of 3,000 volts, which suppresses everything but the top fifth of the wave so that we get a discontinuous constant current with a 20 per cent ripple and the effective voltage relatively near the peak.

In recent tests the equivalent voltage was found to be close to 780 kv. The wave length of this voltage is 0.016 Ångström units. At the peak voltage the wave length is 0.012 Å.

Naturally we were concerned first with the depth dose. Our routine roentgen therapy installation of 200 kv. constant potential using a Thoraeus filter, equivalent to 1 mm. copper, at 70 cm. distance and with a 20 cm. portal, gives readings of 14 r per minute in air, 20.3 r on the patient's abdomen and 2.3 r on his back 20 cm. below the surface. Taking the radiation in air at 100, the dose on the skin is 146 r, and at 20 cm. it is 16 r. In other words, the surface dose is nine times the depth dose at 20 cm. and the back-scattering is 46 per cent. These figures emphasize the importance of stating dosage in terms of units measured on the skin rather than in air. Under these conditions a dose given as 800 r actually means nearly 1,200 r on the patient. With 900 kv., using the same portal and skin distance but with 3 mm. of lead filtration, the figures are (taking air as 100) 112 r on the surface of abdomen and 24 r at 20 cm. below it. The skin dose is now less than five times the depth dose and the back-scattering is only 12 per cent. The maximum at a 90 cm. distance is 60 r so we are getting 40 per cent of the possible radiation through a 20 cm. patient. The practical advantage is that a more homogeneous radiation is secured throughout the area under treatment. How much that means in clinical results is still to be demonstrated.

We have treated about 300 patients, of whom many are dead, but these were desperate cases to begin with. The routine technique has been to administer daily doses of about 200 r to one or more portals until ten treatments have been delivered to each area. Allowing for the daily loss and for the energy coming through from opposite portals, the residual radiation on the skin builds up to about three-fourths of the total dosage applied to an area. In treating carcinoma of the cervix, 2,000–3,000 r is administered through 20 cm. portals front and back within a period of three weeks. Practically all the patients develop a diarrhea within a week which responds fairly well to opiates and clears up within a week or so after the treatments are discontinued. We have had no cases of bladder irritation. Some heavy totals have been administered; 5,000 r was applied a year ago to a woman's chest, in the treatment of a mediastinal malignancy, without permanent damage to the skin.

* Read at the Thirty-sixth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 24–27, 1935.

Another woman received a total of 3,300 r on each of two portals, one in front and the other on the back of her chest. The skin peeled off between three and six weeks afterward. It healed completely in two months and now, one year later, there is only a residual tanning without telangiectasis. The breast tumor has so far shown no signs of recurrence. Another patient was given 3,500 r front and back for a carcinoma in the upper inner quadrant of the breast. Her skin reaction was moderately severe but cleared up entirely in six weeks. She returned eight months later with a skin entirely normal but with a recurrence of the carcinoma locally and in the supraclavicular areas. Here was a breast carcinoma uncontrolled by a dose which was built up to a total in the tumor of 2,500 r. A patient with a pharyngeal tumor received 3,500 r through each of three portals about the neck and although the mucous membrane disappeared from his mouth and throat for two weeks and the skin of his face and neck peeled completely, no permanent damage resulted. The tumor, supposed to be relatively sensitive to radiation, is now recurring six months later. His skin is dry but otherwise normal and his hair is returning.

These cases mean that we will have to go to higher dosages or more prolonged courses of treatment for better results. Whether the patient can stand the cure is the important question.

I would not like to give the impression that most of our cases have been failures. From what can be observed in the routine of a clinic they do about as well as those treated at 200 kv. Certainly there is no striking improvement in the primary results either in our judgment or in that of the clinicians who are following the cases. Any real difference will have to be looked for in five and ten year figures.

We have demonstrated that the skin will stand up to 3,500 residual roentgens of this sort of radiation without damage, and probably the limit has not yet been reached. We are not sure how long doses of this magnitude can be maintained with safety as so far no one course of exposures has run over six weeks.

We have given up the routine treatment of breast malignancy at high voltage because of the development of severe and disabling fibrosis of the lung coming on three to six months after the cessation of treatment and lasting for months or years. In the early cases we thought we might be dealing with tumor recurrences but the autopsies showed no evidence of carcinoma, only a massive fibrosis. It is accompanied by severe dyspnea and a racking dry cough, both of which last for months.

It has been suggested that such highly penetrating rays which cause less scattering on the surface and within the patient and less permanent damage to the skin are also less effective against malignancy. We hope to be able to present a definite answer to this question in the near future. Our experience so far would not indicate that such is the case.

Theoretically a homogeneous radiation should give better results in the long run. We are now in a position to build up a dose of 4,000–5,000 r internally, which is probably pretty close to the tolerance of the normal tissues. The future of this type of therapy would seem to lie in finding out how much higher we can go in dosage and how much longer such levels of intensity can be maintained with safety to the patient.*

* For discussion, see page 378.

# ONE AND ONE-HALF YEARS' EXPERIENCE WITH SUPERVOLTAGE ROENTGEN RAYS*

## WITH SPECIAL REFERENCE TO CARCINOMA OF THE URINARY BLADDER AND CERVIX UTERI

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RECENT interest in supervoltage roentgen rays has been almost as spirited as the controversy over the advantages of supervoltage over 200 kv. roentgen rays in the treatment of cancer. It is not our intention to try to settle this dispute. The number of patients treated and the experimental work performed during the one and a half years' existence of the machine are far too inadequate to do more than give primary results observed in a small group of similar cases. The small number treated is due in part to the newness of the institution and to the fact that the majority of cases treated are private patients paying a scheduled fee for their treatments. The clinic cases amount to only a few from regional counties, which counties are prepared to defray the patients' expenses during hospitalization. It may also be noted that the time has not yet come when one is justified in treating more than a minority of cancers by supervoltage roentgen therapy alone to the exclusion of radium and surgery.

### DESCRIPTION OF APPARATUS

The installation is a General Electric KXC-2 whose circuit is essentially a Villard voltage doubler.[4] In brief, it consists of two 200 kv. (peak) center-tapped secondary transformers with a capacitor in each secondary leg. Equipped with four 200 kv. (peak) kenotrons, the condensers are charged during one-half of the cycle and discharged in series with the transformer secondary during the other half thus doubling the voltage. The apparatus is equipped with a 75 cm. sphere gap for voltage measurement. The large error in the present A.I.E.E. Standard spark-over curve[1] for 75 cm. spheres has been corrected to read true voltage by calibration with a rotary voltmeter up to 830 kv.[8] (peak). Since the voltage wave form of a roentgen-ray generator is probably much more important than a peak voltage determination, this was accurately measured by means of the rotary voltmeter and need not be presented here since it has already been published.[8] Current wave forms have been obtained with an oscillograph.

The roentgen tube is a four section accelerator designed by Coolidge. It is about 14 feet long and consists of four soft glass cylinders cemented to brass castings supporting the intermediate sleeves. A water-cooled extension chamber houses a 4 inch tungsten target 100 mils thick on a copper back, the chamber being grounded through the milliammeter. The electron path is about 13 feet and focusing is accomplished magnetically.[4] Roentgen-ray output and penetration are vastly improved by "mechanically biasing" the filament, i.e., by withdrawing the filament into the focusing cup in the cathode support. The tube is continuously pumped during operation by an oil diffusion pump backed with a high-speed mechanical pump. No refrigerant is required, activated charcoal being used as a trap which can be periodically out-gassed by heating, thus eliminating a large item in operating expense.

An operating vacuum of about $5\times10^{-6}$ mm. to $2\times10^{-5}$ mm. of mercury is ordinarily maintained although the tube will still operate with pressures as high as $10^{-4}$.

This tube is notable inasmuch as no leak has developed and has not been under atmospheric pressure for thirteen months. The present filament has been in operation for the same period, representing about 800 hours of service. The target is the original as installed. Out-gassing the charcoal trap is only necessary about every three to five months and can be accomplished without greatly lowering the tube pressure. During this thirteen month interval only five

* Read at the Thirty-sixth Annual Meeting, American Roentgen Ray Society, Atlantic City N. J., Sept. 24–27, 1935.

treatment days have been lost due to shutdowns.

A lead extension chamber shield 6 inches thick located in the roof of the treatment room houses the target and a single port is directed downward. The treatment room is a concrete cell with walls 2 feet thick and the floor 3 feet thick. The use of concrete replaced 30 tons of lead, and furnishes complete protection, no stray radiation being detectable. A 2 inch lead door closes the cell and a large aperture periscope furnishes a view of the patient.

The lead-lined treatment cone is interchangeable as are a large variety of 1 inch thick lead diaphragms.

In the treatment cone support is mounted a motor-driven 1 inch lead shutter which when open operates a clock timing the exposure. Mounted above the shutter and below the filter is a sealed ionization chamber connected to a galvanometer and standard cell network. Temperature and barometric pressure variations have no effect on the calibration. Galvanometer sensitivity is held constant by an Ayrton shunt and standard cell network.

### TREATMENT FACTORS

For the past eight months the apparatus has been operating at not less than 800 kv. (peak) (rotary voltmeter) and 10 ma. All patients during this period have been treated at this voltage with a filter consisting of 3 mm. of brass plus 1 cm. of water (inherent filter) plus 2.6 mm. of lead. The secondary filter is furnished by the ionization chamber containing 2 mm. of aluminum, and there is 1 mm. aluminum and 5 mm. of celluoid in the diaphragm support. Previous to this time the voltage was somewhat lower due to the error in the sphere gap calibration. These treatments were carried out at 735 kv. (peak) with an added filter of 2.1 mm. of lead, the other factors being the same.

Since it may be desirable to avoid skin contact even with such light material as celluloid, the patient is placed 10 cm. from the diaphragm, a removable pointer locating the center of the beam.

All treatments have been carried out at 70 cm. target skin distance and at an intensity of 60 "equivalent" r per minute, the filter having been adjusted to give this intensity for the two voltages mentioned. A definition of the term "equivalent" r is perhaps necessary. Up to the present time no really satisfactory method for measuring the roentgen under its present definition above 600 kv. (peak) is available. At 600 kv. (peak) and below, the air chamber with certain limitations[9] can be used with a fair degree of accuracy. Until this matter is somewhat more settled it was decided that the use of an instrument, calibrated at 200 kv. (peak) and available to all laboratories, was the best to use. Thus readings could be reproduced in other laboratories and a correction later made to the absolute value. The instrument most readily available seemed to be the Victoreen condenser type dosimeter with which all our intensity readings were taken. As it turns out these measurements seem to be not more than 20 per cent higher than the true roentgen as defined at present. Throughout the case reports and discussions we have omitted the constant repetition of the word "equivalent" r but its use is implied.

Measurements made with the Victoreen dosimeter indicate a half-value layer in lead of 2.8 mm. for 800 kv. (peak), using an added filter of 2.6 mm. lead; that is, therapy conditions.

Depth dose measurements made in a water phantom with the Victoreen dosimeter indicate a 10 cm. depth dose of 45 per cent. Using a very thin-walled (0.1 mm.) celluloid chamber, similar to one used by Failla and his associates,[6] the 10 cm. depth dose is 50 per cent. Neither chamber is satisfactory for this purpose. By selecting the chamber the depth dose can be made any value desired. Very obviously more work must be done on this subject.

A limited series of skin tests have been carried out using the threshold erythema as defined by the Memorial Hospital group.[11] The period of observation of the tests was lengthened to six weeks as the reaction often appeared only after the third

week and persisted for six or more weeks. Using a 5×5 cm. skin portal on the anterior aspect of the mid-thigh, the threshold was found to be 1,000 "equivalent" r ± 5 per cent.

In the year and a half that the machine has been running, all types of cases of cancer have been treated, in fact wherever possible preference was given to it over the 200 kv. (peak) machine. With the aid of various-sized lead ports, pointers, pillows and a table which can be elevated or lowered as well as moved horizontally in any direction, we have found that it is practically as handy to use as the 200 kv. unit (which happens to be one of the latest model shock-proof oil-cooled installations). The larger portion of patients treated consisted, naturally, of that hopeless group of very advanced lesions in which only some palliation could be hoped for. Speaking in general, we may say that there was an advantage in using the higher voltage on these cases for we were able to get in perhaps slightly more treatment with much less localized reaction and certainly no more generalized reaction than with the lower voltage tubes. From clinical observations, we are convinced that 800 kv. roentgen rays have a distinct advantage in depth dose over 200 kv. roentgen rays, and that this advantage becomes more apparent when smaller portals are used.

Excellent primary regression has been obtained in a few cases in almost every type of neoplastic disease in which the 200 kv. units might be effective, such as carcinoma of the antrum, floor of mouth, mucosa of cheek, and tonsil. These miscellaneous cases are of no value for comparisons at this early stage of their course, for we know that this is frequently seen with 200 kv. roentgen rays, only to be followed by later recurrences in many. Amid all this there have been two small groups of cases—carcinoma of the urinary bladder and cervix uteri—which have done well enough to be encouraging and to afford us, as it were, a yardstick with which we can measure progress. We have also chosen these two groups to discuss because we feel that the accomplishment of a complete primary regression of the disease in them means more than in other varieties of cancer. These two types are fairly readily accessible and the regression, persistence or recurrence of local disease may be followed with at least some degree of accuracy.

In the first group, advanced carcinoma of the bladder, a total of 10 cases was treated with the supervoltage machine. This number includes all cases treated in which roentgen irradiation was the principal means of treatment or which received any appreciable amount of roentgen treatment. One may see, later, that it even includes 2 cases credited as failures when the roentgen radiation was given only as a last resort after failure by other methods—certainly an unfavorable set-up upon which to judge regression from roentgen irradiation. All cases had a thorough urological examination preceding treatment and represent a group for which no hope could be held out by any other of the present recognized forms of treatment. Histologic examination of specimens removed from each case verifies the diagnoses and in most instances allows grading of the carcinoma. Six of the 10 cases (marked with an asterisk) have been reported previously by Nelson.[12]

## REPORT OF CASES

### *Ten Cases of Advanced Carcinoma of Urinary Bladder Treated by Supervoltage Roentgen Rays*

CASE 1.* H. M., a Japanese male, aged fifty-eight, who gave a history of a suprapubic operation one year before admission. A tumor of the bladder had been removed locally by electrocautery at this operation. The suprapubic wound had not healed and practically no urine had been voided through the urethra since this operation. On examination the vesical neck was stenosed and a hard tumor 8 cm. in diameter involved the entire floor of the bladder. A transurethral resection of an obstructing prostatic bar was performed. A biopsy taken from the bladder showed a papillary epidermoid carcinoma Grade III.

The patient was given 300 r daily, alternating a center anterior with a center posterior pelvic portal 12×12 cm. for a total of 3,000 r to each field in thirty days. Six weeks later the urinary fistula had healed and cystoscopic examination revealed no evidence of the previous disease. He has gained weight, feels perfectly well and now, a year following treatment, shows a normal urine, has no frequency, and shows no evidence of disease cystoscopically.

Case II. C. R., a white male, aged fifty-four, with a history of frequency (once an hour), dysuria, marked loss of weight and pain in lower abdomen radiating to testes for six months but no hematuria. One month previous to admission a transurethral resection of the bladder neck had been done to relieve obstruction, and a biopsy taken from the bladder showed epidermoid carcinoma Grade II. Since then he had been given morphine hypodermically five or six times a day. On admission he was in severe pain, extremely emaciated, and markedly anemic (hemoglobin 55 per cent, red blood cells, 2,900,000). Cystoscopic examination revealed a large fungating, partially necrotic tumor mass occupying the entire left half of the urinary bladder and apparently obstructing the left ureteral orifice. On rectal examination a mass could be felt extending downward to the prostate and left seminal vesicle.

He was treated in spite of the advanced condition, with the idea of palliation only and treatments to be stopped if his condition became any more critical. A total of 3,850 r was given to the center anterior pelvis and 3,150 r to the center posterior pelvis through 14×10 cm. skin portals in daily doses of 350 r to one portal a day during a period of twenty-four days. The reaction from this was very mild and he obtained only slight relief of pain. His condition grew steadily worse and he died three and a half months after completing treatments.

Case III. F. G., a married white female, aged seventy, gave a history of hematuria of two years' duration. Cystoscopic examination revealed a soft friable papillary tumor which the urologist stated was so extensive that he was able to find only occasional areas of normal-appearing bladder mucosa. The bladder tumor was palpable bimanually as a large doughy mass. Biopsy showed a papillary epidermoid carcinoma Grade III.

The patient was given a total of 4,550 r to the center anterior pelvis and 3,500 r to the center posterior pelvis through 14×10 cm. skin portals in daily doses of 350 r to alternate fields over a period of thirty-six days.

Bleeding stopped after the third week of treatment. A week after the completion of treatments the patient had a fairly marked skin reaction in the form of intense erythema but only slight vesiculation. One month after treatment the patient felt perfectly well, the skin was entirely healed but there was some edema of the lower anterior abdominal wall and bladder. Five weeks after treatment, cystoscopic examination showed regression of all of the disease except a small suspicious doughy area near the base of the bladder. It was felt that this was probably only edema and no biopsy was taken but to insure a better prognosis 12 mc. in gold radon seeds was implanted through the cystoscope into this region. The suspicious remaining doughy area slowly disappeared following this and the patient has been clinically and cystoscopically free of disease for nine months.

Case IV.* D. F., an obese married white female, aged sixty-eight, gave a history of dysuria and hematuria of four months' duration. One month before admission a papillary tumor 8×10 cm. involving the left lateral wall and trigone of her bladder had been fulgurated and the redundant portions removed with the resectoscope. This material showed an epidermoid carcinoma Grade IV. On admission the tumor had extended to the anterior wall of the bladder.

She was given a total of 3,600 r to the center anterior pelvis and 3,000 r to the center posterior pelvis over a period of thirty-nine days. The treatments were 300 r to a single 12×12 cm. skin field daily, alternating the anterior and posterior portals. One month after the beginning of treatment the tumor had entirely regressed. The skin reaction was quite mild, the anterior pelvis showing only a deep brown color. She had gradually decreasing dysuria for three months after treatment. Her urine has been normal and she has been free of disease cystoscopically for fourteen months after treatments.

Case V.* J. C., a white male, aged sixty, was referred with a history of having had a transurethal resection of a benign adenomatous obstructing prostate two months previously. At the time of this operation a papillary carcinoma, histologically an infiltrating carcinoma, Grade III, 4×4 cm. on the right bladder wall near the base of the trigone was fulgurated. At

the time of admission the tumor had extended to involve both lateral walls and the trigone.

He was given 300 r daily through a 12×12 cm. skin portal, alternating the center anterior with center posterior pelvis for a total of 3,000 r to each of the two fields in thirty-six days. In this instance, a marked but not severe skin reaction was obtained. The tumor had apparently regressed entirely a week after the completion of treatments. Three months later, during a routine cystoscopic examination, an apparently new growth was found on the fundus and left bladder wall. No biopsy was obtainable from this area. Treatments were started again and he was given an additional 1,400 r anteriorly and 700 r posteriorly in daily doses of 350 r through a field 14×10 cm.

The patient has now gone ten months since these treatments without evidence of recurrence, and is symptom-free. Periodic cystoscopic examinations reveal occasional shifting small areas of edema, and the occurrence of these makes one feel that the area previously described as a recurrence was no more than congestion and edema. His subsequent course may prove this supposition fallacious.

CASE VI.* M. L., a married white female, aged sixty-seven, had a papilloma of the bladder removed twelve years before admission. She complained of hematuria and frequency of one year's duration. On cystoscopic examination an infiltrating growth was found involving almost the entire trigone, extending downward toward the urethra and upward on the vault and left wall for a distance of 4 cm. A specimen for histologic examination showed papillary carcinoma Grade IV. This patient was one of the first treated by means of the 800 kv. roentgen rays and illustrates the caution used in building up to the use of higher dosages. It also shows the failure to give complete regression of disease. The following treatments were given:

| | *Center Anterior Pelvis* | *Center Posterior Pelvis* | *Factors Used* |
|---|---|---|---|
| (1) | 2,100 r | 2,100 r | 300 r daily. 12×12 cm. skin portal in 15 days. |
| | Interval of three weeks without treatment. | | |
| (2) | 1,200 r | 1,200 r | Factors same as above in 8 days. |
| | Interval of three weeks without treatment. | | |
| (3) | 900 r | 900 r | Factors same as above in 7 days. |
| | Interval of nine weeks without treatment. | | |
| (4) | 2,100 r to anterior pubic region through a 9 cm. skin circle in daily doses of 350 r. | | |

The tumor was still present three weeks after the first cycle so a second series with a smaller total dosage was given. The skin showed very mild reaction following these two series of treatments. There was still residual disease in the bladder so a few more treatments were added (three weeks after the previous ones—see table). The patient was again closely observed clinically and cystoscopically. The induration disappeared temporarily and the patient seemed free of disease for a period of five or six weeks, but then an indurated area appeared in the form of a bar of tumor tissue traversing the posterior commissure of the bladder. The fourth series of treatments was then given and at the end of them 10 mc. in gold radon seeds was implanted cystoscopically. It seemed as if this might control the disease but three months later there was a local recurrence which was followed a month later by a stony hard supraclavicular metastasis. The patient died apparently of pulmonary metastases eleven months from the time treatments were started.

CASE VII. F. T., a white male, aged seventy-five, with a history of hematuria for three months, was referred for treatment. He had received only five treatments of 300 r each when a suprapubic cystotomy had to be performed because of bleeding. A tumor 6×7 cm. was found on the right wall of the bladder. The mass was coagulated with the cautery to control bleeding. Specimens for biopsy showed papillary epidermoid carcinoma Grade IV. He did not resume treatments until two and a half months later and was given only 1,800 r to each of two portals. This gave the patient sufficient palliation to allow him to pick up strength but he subsequently developed a perinephritic abscess requiring incision and drainage. It was four months longer before he could go on with treatments. He then received another 1,400 r to each of two pelvic portals—treatments being stopped again because of family troubles at home. Although he is still alive and feels well fifteen months after beginning treatment he has recently developed hematuria.

CASE VIII.* A. B., a white male, aged sixty-six, previously reported by Nelson, is not taken up in detail here as he was treated primarily by fulguration and interstitial irradiation: 23 mc. in 14 gold seeds. Two months later there was extensive disease in other areas of the bladder and he was then given 3,500 r to each of two 12 cm. circular skin portals in doses of 350 r daily. This gave him very little relief of dysuria

and frequency, he grew steadily worse and died six months after the original interstitial irradiation and about three months after completion of the roentgen therapy. At the time he died there was extensive disease in the bladder which protruded through the old suprapubic incision.

Case IX.* C. W., female, white, widow, aged fifty-eight, who complained of hematuria, frequency, and dysuria of two months' duration. Cystoscopic examination revealed a fungating tumor about 4×5 cm., involving the right wall and floor of the bladder. The tumor had infiltrated through the bladder and extended into the vesicovaginal septum. Biopsy taken from the bladder showed solid epidermoid carcinoma Grade IV.

She was given 4,200 r to center anterior and 4,200 r to center posterior pelvic fields measuring 12×12 cm. on the skin. The treatment period was thirty-three days and 350 r was given daily to a single field. A moderate skin reaction was obtained. Bleeding ceased before the treatments were completed. Six weeks after the completion of treatment the induration in the vesicovaginal septum remained and the area of the bladder above this contained residual disease. The skin of the abdomen was well healed and soft so a suprapubic cystotomy was performed and 21 gold radon seeds totalling 29 mc. were distributed in the small residual bladder tumor and its larger nodular outward extension. The suprapubic wound healed fairly well but later broke down and drained urine for almost a month. Three months after the above procedure only slight thickening remained in the treated area and no disease could be seen cystoscopically. The patient is now (8 months after insertion of radium and 10 months since completion of roentgen irradiation) symptom-free and shows no evidence of disease.

Case X. N. F., a white male, aged fifty-nine, with a history of frequency, dysuria and hematuria of three months' duration. He was cystoscoped and a large fungating lesion involving most of the right wall and the floor of the bladder was found. The redundant portions of the mass were fulgurated and he was then referred for treatment. Biopsy showed transitional cell carcinoma Grade III.

He was given 4,900 r to the center anterior pelvis and 3,150 r to the center posterior pelvis through 12 cm. circular skin portals; 350 r was given daily and the skin fields were alternated. He had a moderately severe reaction which was entirely healed five weeks after treatment. He has now remained symptom-free and cystoscopically free of disease for eight months.

### SUMMARY AND DISCUSSION OF ABOVE TEN CASES

Analysis of these 10 brief case reports shows the following:

Four cases (Cases I, IV, V and X) which have complete primary regression of disease that has now lasted from eight to fourteen months without recurrence.

One case (Case III) which probably had complete primary regression of disease but to which 12 mc. of radon in gold seeds was added cystoscopically five weeks after completion of the roentgen therapy. This case has gone nine months without recurrence.

One case (Case IX) in which the major portion of the bladder tumor regressed but had 29 mc. of radon in gold seeds inserted through a suprapubic cystotomy route in the extra vesicle extension and mucosa over it five weeks after completion of the roentgen therapy. This case has now gone eight months without evidence of recurrence of disease.

Four cases (Cases II, VI, VII and VIII) in which neither primary nor late complete regression of disease was obtained. One of these cases is living fifteen months after treatment but the others died eleven, three, and three and a half months after completion of roentgen treatments. In this group we find 2 of the first cases treated (Cases VI and VII). If the total number of roentgens given to any one portal was added it would appear as though the patient received a fair amount of treatment, but actually each small series was given at such long intervals as to make the total far too inadequate to control any kind of disease. The cases did serve to give an approximate idea of the amount of treatment a patient could stand and to show that therapy given in such a manner as the above was inadequate to control the disease but would prolong life and afford moderate palliation. In one of the remaining two of this group (Case II), the disease was hopelessly beyond control;

while in the other (Case VIII) it may be said that the tissues, following extensive fulguration and later interstitial irradiation with radon in gold seeds, were hardly in a condition to respond favorably to intensive roentgen treatments.

It will be noted that most of these cases were treated with only two skin portals, a center anterior and posterior 12 cm. circular skin portal, the smallest dose given being 3,000 r to the anterior and 3,000 r to the posterior field while the larger doses were 4,200 r to each of two opposing fields. By this type of set-up all the treatment given was the most effective treatment that could be given to the bladder itself without irradiating the whole pelvis.

We wish to point out here that too much emphasis cannot be placed on infinite care in setting up a patient for treatment. In the bladder cases the bladder is emptied just before the patient is placed on the table. In some cases, to make sure that we are accurately reaching the empty bladder with anterior and posterior portals, we marked a central point on the skin of the back and suprapubic region with the patient on a roentgenoscopic table and an ounce of lipiodol solution injected into the empty bladder.

The use of smaller skin portals and small numbers of portals in our bladder cases is partly justifiable on the basis that disease in this region tends to remain localized for a fairly long period[2] and to metastasize in a relatively small percentage[3] of patients. Throughout the treatment of these patients there has been the feeling (perhaps another clinical impression) that the general health of few if any patients could tolerate these large amounts of treatment to more than two or three areas. In treating intraoral or laryngeal cancer, it is usually advantageous to use as small portals as is feasible with the size of the tumor.[10] Is this not also applicable to the pelvis? Will the increased number of patients saved by means of a greater dosage throughout the pelvis as a result of a greater number of skin portals outweigh the number lost as a result of too widespread irradiation? A happy balance may be brought about by smaller daily doses to two or more portals, and then increasing the total number of skin portals as well as the total treatment time. This has been done in the more recently treated cases of carcinoma of the bladder as well as the cervix uteri. The distance may likewise be changed to 100 cm. The increased time does not become a detrimental factor to us because of the high output of the tube.

In a case reported by Dean[5] of advanced carcinoma of the bladder, well for two and a half years following treatment by 700 kv. (peak) roentgen rays alone at the Memorial Hospital, the dosage to the bladder tumor is estimated as 10 S.E.D. in three and a half months. This was obtained by using six 15×10 cm. skin portals; the treatment was given in two series six weeks apart.

We do not attempt to estimate the dosage received by the tumor in the cases presented above. It obviously falls far short of the dose described by Dean, yet complete primary regression has been obtained in many of the cases.

### CARCINOMA OF THE CERVIX UTERI

Between 90 and 100 cases of cancer of the cervix have been treated during the last three years at the Tumor Institute of the Swedish Hospital in Seattle. About half of these have been treated during the last year and a half, yet we have only 7 cases in which the treatment of choice was supervoltage roentgen rays. By that we mean that we believe, as do most others, that radium alone, or better, combinations of radium and roentgen rays, or rarely that combination with surgery, afford the best chance of cure in cancer of the cervix uteri. It follows, therefore, that all cases possible should have the generally recognized preferable form of therapy. We knew by personal observation and later from the report by Healy and Arneson[7] that primary regression could be obtained by the use of large amounts of fractional doses of 200

kv. roentgen rays alone in cancer of the cervix. In this instance, however, the 200 kv. roentgen rays had been given as a preliminary to radium therapy. We knew that this regression was only very temporary and that it was not even apparently complete in most instances. On the other hand, most cancer therapists recognize a certain group of advanced cervix carcinomas which they believe will not do well under radium therapy or for some reason cannot be adequately treated with radium. The 7 cases reported here fall in this group. They also represent the total number of cases treated primarily by the supervoltage machine or in which this was the planned form of therapy. Another much larger series of cases treated by supervoltage roentgen rays combined with radium will, in the future, afford an excellent group for comparison with similar groups treated by us, as well as others, with 200 kv. roentgen rays and radium. Histologic examination of specimens from each case verified the initial diagnosis in the 7 cases presented below.

*Seven Cases of Advanced Carcinoma of the Cervix Uteri Treated by Supervoltage Roentgen Rays (Includes 3 Cases of Cervical Stump Carcinoma)*

Case xi. M. C., female, white, widow, aged seventy-two, with a history of vaginal discharge for two years, and vaginal bleeding, dysuria, and frequency of urination for two months. On examination a large friable mass filled the entire vaginal vault and infiltrated into the anterior vaginal wall and bladder. On cystoscopic examination the growth was found to involve almost the entire trigone of the bladder. Unfortunately no biopsy was taken from the bladder. The biopsy from the cervix showed epidermoid carcinoma Grade iii.

Treatment with 800 kv. roentgen rays was given. A total of 3,850 r to a center anterior pelvic field and 2,450 r to a center posterior pelvic field through 12 cm. circular skin portals and 1,050 r to each left and right posterior pelvic fields through 14×10 cm. skin portals in doses of 350 r daily were carried over a period of thirty-nine days. A blood transfusion was given during the course of treatment because of secondary anemia and general debility.

Two months after completion of treatments the patient was symptom-free and no evidence of disease could be found in the cervix or bladder. She has remained this way to the present—ten months after treatment.

Case xii. B. F., a nulliparous, white, female, widow, aged sixty-nine, with a history of severe vaginal hemorrhage for one and one-half months. She weighed 201 pounds and had a blood pressure of 240 systolic and 100 diastolic. Pelvic examination revealed a vaginal tube so stenosed that a finger could not be inserted. On rectal examination an enlarged boggy cervix could be palpated and the parametria seemed thickened. Curettings from the vaginal vault showing epidermoid carcinoma Grade ii.

The patient was given 2,800 r to the center posterior pelvis through a 14×14 cm. skin portal, 2,800 r to the center anterior pelvis through a 9 cm. circular skin portal and approximately 1,000 r to each of 4 pelvic fields (left and right anterior and left and right posterior pelvis) through 12×12 cm. skin portals in doses of 350 r daily to one field in a total of sixty-one days.

She had a marked reaction on the skin of the back and groins, amounting to denudation of the superficial epithelium with exudation of serum and later crusting. This had healed entirely three weeks after completion of treatment.

She has now remained symptom-free and shows no palpable evidence of disease ten months after treatment.

Case xiii. E. P., a white female, aged seventy-one, who complained of severe dysuria, frequency, hematuria and a vaginal discharge of six months' duration. She had an extensive lesion which had infiltrated into the bladder, giving rise to a bladder tumor some 7 cm. in diameter, which showed an epidermoid carcinoma Grade iii; 3,500 r was given to a 12×12 cm. center anterior pelvic portal and 2,800 r to a 12×12 cm. center posterior pelvic portal in thirty days. The patient did not do well. There was only partial primary regression and it was deemed unwise to continue further treatment because of the advanced stage of the disease as well as her poor general condition.

She continued to suffer mainly from bladder symptoms and died nine months from the time she began treatments. Autopsy revealed extensive disease throughout the pelvis, with its origin in the cervix, a vesicovaginal fistula, and bilateral hydronephrosis.

CASE XIV. H. S., a white married female, aged forty-two, had a history of two miscarriages and an operation six years previously for an ovarian cyst. During the six months before admission she had been bleeding almost continuously. Physical examination revealed a fibromyomatous uterus the size of a four months gestation. The entire cervix was the seat of an ulcerated, granular, friable growth which presented a crater 2 cm. in diameter in the region of the external os. The cervix was not movable with the uterus. Biopsy of the cervix showed an epidermoid carcinoma Grade IV.

She was given 1,400 r to each of six fields in thirty-three days, 350 r daily. Four skin portals (left and right anterior and posterior) were 14×14 cm. and two (center anterior and posterior) were 14×10 cm. Treatments had to be discontinued at this point because of a severe skin reaction. One month later there was still residual disease so that radium was used in the cervical canal; 2,000 mc-hr. was given in two rubber covered 0.5 mm. platinum filtered capsules. There was a marked reaction from this treatment. The disease did not entirely regress; she began bleeding again three months later, and died from an acute hemorrhage two days later.

CASE XV. F. F., a white married female, aged fifty-three, who had had a supracervical hysterectomy twenty years previously for a fibroid tumor. When first seen on October 10, 1934, she complained of vaginal bleeding of six months' duration. On examination, an ulcerated granular growth 5 cm. in diameter seemed to replace the cervix and filled the vaginal vault. There was shortening of all fornices and the parametria were thickened and boggy. Biopsy showed an epidermoid carcinoma Grade III.

Treatment was instituted with the supervoltage machine. Patient was given 1,400 r to each of four pelvic fields (left and right anterior and left and right posterior), through a 14×10 cm. skin portal and 2,450 r to the center anterior and 2,450 r to the center posterior pelvis also with a 14×10 cm. skin portal in doses of 350 r daily to a single field. There was slight overlapping of fields near the midline. The total treatment time was forty-eight days.

She suffered a moderate amount of generalized reaction in the form of weakness. There was mild proctitis. The skin reaction was termed moderate, meaning a deep erythema—with late scaling but no blistering. A month after completion of treatments the cervix was entirely healed. An external os could be identified but a sound could be introduced less than 1 cm. Only a very small cervical stump remained. Four months after treatment she had gained 20 pounds in weight, was doing all her own housework and was symptom-free. She has now remained free of disease for ten months.

CASE XVI. E. R., a white married female, aged sixty-one, had 5 children living and well, the youngest being twenty-two years old. Her cervix had been repaired four years before because of an old laceration. Nine months before admission a complete hysterectomy had been attempted because of a carcinoma of the cervix but only a supracervical hysterectomy was performed. The disease progressed and she was finally referred for palliative treatment. On admission a soft friable bleeding mass 4 cm. in diameter covered most of the stump of the cervix and extended into the left vaginal vault. Biopsy showed epidermoid carcinoma Grade III.

The treatments given with 800 kv. roentgen rays totalled 1,400 r to each of four pelvic fields (left and right anterior, and left and right posterior pelvis) through 14×10 cm. skin portals, and 2,450 r to both the center anterior and center posterior pelvis through a 14×10 cm. skin portal in doses of 350 r daily to a single field. There was slight over-lapping of the lateral and central fields. Total treatment time was thirty-eight days.

This patient had a more marked local reaction in the form of a pseudo-diphtheritic membrane covering the vaginal canal and extending out to the urethra, and this reaction persisted in the vaginal vault for five weeks.

Although the cervix healed entirely, there was evident residual disease in the left fornix six months after treatment in the form of slight ulceration and a recurrence of bleeding. Additional roentgen treatment, 1,200 r to each of four pelvic fields (two anterior and two posterior through 14×10 cm. skin portals at the rate of 350 r daily) was given; 750 mg-hr. of radium (filtered with 0.5 mm. platinum capsule and 0.75 cm. of rubber) was also given to the left vault.

Three months after this (and ten months after the beginning of treatment) only slight thickening remained in the left vault and the patient was again symptom-free.

CASE XVII. E. W., female, white, widow, aged

seventy, had 3 normal deliveries and 1 miscarriage before her menopause at the age of fifty. At the age of sixty-two, eight years before admission, a supracervical hysterectomy had been performed in which both tubes, both ovaries and the uterus had been removed because of a fibroid tumor.

Her present illness consisted only of vaginal spotting of one week duration. On examination a cervical stump could be palpated measuring 2.5 cm. in diameter and completely covered with a finely granular, ulcerating, bleeding carcinomatous tissue which extended into all vaginal vaults. All fornices were shortened and the right parametrium seemed thickened. Biopsy taken from the cervix showed epidermoid carcinoma Grade III.

This patient was given 4,550 r to the center anterior pelvis and 4,200 r to the center posterior pelvis through 12 cm. circular skin portals in doses of 350 r daily to a single field in a total of thirty-nine days. One week after the completion of treatments she had a severe reaction on the skin of the anterior and posterior pelvis. This reaction was well localized to a circle not more than 13 cm. in diameter and there was denudation of the superficial epithelium. The reaction in the vagina was less severe but there was almost complete regression of disease. Three and a half weeks after treatment the skin had entirely healed, the cervical stump still felt hard and slightly nodular, but there was no bleeding.

Three months after treatment the cervix was entirely healed and no evidence of disease could be found. She has remained symptom-free and with no evidence of disease for six months.

### SUMMARY AND DISCUSSION OF ABOVE SEVEN CASES

The last 3 of the 7 cases were carcinomas in cervical stumps. Two of the 3 have shown complete primary regression of disease for ten and six months, the other one has been apparently free of disease for ten months but roentgen therapy was supplemented by a small amount of radium (750 mc-hr. at 1 cm. distance, to the left side of the vaginal vault) and remains doubtful.

Two of the 4 regular cervix cases have shown complete primary regression of disease which has persisted for ten months. The other 2 did not show complete primary regression and died four and nine months after completion of treatment. It may be noted that these 2 also received the smallest amounts of treatment of the cervix cases; one having been treated like a bladder case because of the prominence of bladder symptoms. Both also represented in the beginning the most hopeless prognoses possible. It may be noted that the cervix cases received a larger total dosage than did the bladder cases; a minimum of 3,000 r to each of two portals, and a maximum to six pelvic portals made up of 1,400 r to each of four lateral pelvic portals plus 2,450 r to each of two opposing central portals.

Six portals were used in most cases, as it is a well-recognized fact that the inability to cure a higher percentage of cervix cancer than is possible at the present time is not due to failure to control the local disease in the cervix but to failure to control the extension of the disease in the parametria. With the six portals used, the greater proportion of the treatment given in these cases has still been directed toward the cervix itself. It must be remembered that these patients were among the first ones treated on this machine. The technique has varied considerably since then. Thin patients could not stand as much on the sacrum, and fleshy patients could not stand as much on the skin of the suprapubic region, so that with these types additional treatment had to be given on the lateral fields in order to build up the total. The individual patient has to be carefully watched during the latter part of the treatment and the technique modified according to the clinical course.

With the above change in treatments the total treatment period has been lengthened to six or more weeks. Just what the limit of time is that may be taken to treat a given lesion is still problematical.

We wish to stress the point again that we realize that the ultimate cure of these patients treated by supervoltage external irradiation is doubtful. Observations of

primary regression made following radium therapy in similar cases illustrates this premise. The important fact is that 2 of the 3 cervical stump cases and practically 2 of the 4 regular cervix cases have had, to the present time, apparent primary regression of disease for from six to ten months from supervoltage roentgen irradiation alone. This we believe is notable because the treatment given these patients does not represent the most that can be given. With proper planning of treatment, and rigorous care of the patient during and following treatments, the dosage administered to the cervix and pelvis can be increased perceptibly. It so happens that this group of patients was treated mostly with the view of palliation in mind and not a great deal of thought toward ultimate cure.

## SUMMARY AND CONCLUSIONS

A brief description of the 800 kv. roentgen-ray tube used is given.

The factors employed in treatment are given.

Reference is made to the method of measuring peak voltage and wave form.

The rate of complete primary regression of disease in 10 cases of advanced carcinoma of the urinary bladder is given. The diagnosis of each case reported is verified by histologic examination.

The rate of complete primary regression of disease in 7 cases of advanced carcinoma of the cervix uteri (3 of which are cervical stump cases) is given. The diagnosis of each case reported is verified by histologic examination.

Emphasis is placed on the fact that this is a study of primary complete regression and lack of regression of disease following supervoltage roentgen therapy, for from six to eighteen months, and represents the total number of such cases so treated. No attempt is made to give end-results.

Treatment of certain advanced cases of carcinoma of the urinary bladder and cervix uteri by supervoltage roentgen therapy alone is justified.

## REFERENCES

1. A. I. E. E. Standards No. 4.
2. CABOT, HUGH. Modern Urology. New 1936 edition in press. Chapter on Tumors of the Bladder, by Keyes, E. L., and Ferguson, R. S.
3. Committee on the Carcinoma Registry of the American Urological Association. Carcinoma of the Bladder. *J. Urol.*, 1934, *31*, 434–435.
4. COOLIDGE, W. D., DEMPSTER, L. E., and TANIS, H. E., JR. High voltage cathode ray and x-ray tubes and their operation. *Physics*, 1931, *1*, 230–244.
5. DEAN, A. L., JR. Treatment of bladder cancer with external irradiation. *Ann. Surg.*, 1935, *101*, 1428–1432.
6. FAILLA, G., QUIMBY, E. H., MARINELLI, L. D., and ROSE, J. E. Relative effects produced by 200 kv. roentgen rays, 700 kv. roentgen rays, and gamma rays. I. The distribution of radiation in a water phantom. AM. J. ROENTGENOL. & RAD. THERAPY, 1933, *29*, 293–307.
7. HEALY, W. P., and ARNESON, A. N. Radiation treatment of carcinoma of the cervix. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *32*, 646–653.
8. HENDERSON, J. E., GOSS, W. H., and ROSE, J. E. Use of the rotary voltmeter for measurements up to 830 kilovolts. *Rev. Scientific Instruments*, 1935, *6*, 63–65.
9. LAURITSEN, C. C. Energy considerations in high voltage therapy. AM. J. ROENTGENOL. & RAD. THERAPY, 1933, *30*, 380–387.
10. MARTIN, H. E., and MCNATTIN, R. F. The treatment of cancer of the pharynx, tonsil and extrinsic larynx by divided doses of external radiation. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *32*, 717–729.
11. MARTIN, H. E., QUIMBY, E. H., and PACK, G. T. Calculations of tissue dosage in radiation. AM. J. ROENTGENOL. & RAD. THERAPY, 1931, *25*, 490–506.
12. NELSON, O. A. Treatment of vesical carcinoma by external irradiation. Read before a meeting of the American Urological Association, June 29, 1935. To be published in *J. Urol.*

## DISCUSSION*

DR. FRANCIS CARTER WOOD, New York City. The introduction in a few institutions in this country of apparatus delivering between 500 and 1,000 kv. has brought several new problems into radiation therapy. The first is the suppression of optimistic statements to the public and the profession of the results of such high voltage therapy until sufficient observations have been made on patients to warrant such statements. At the present time the laity and most physicians consider the effectiveness of a

* Of papers by Leucutia, Ruggles, and Ward, Wirth and Rose.

roentgen machine running at 1,000,000 volts at five times that of one running at 200,000 volts, an opinion which is absolutely unwarranted. Most of us can remember the extraordinary hopes placed in the 200 kv. apparatus as compared with the lower voltages and the disappointment which followed exaggerated claims. It is obvious from the papers read that the millenium is still some distance away and it is important that everyone realize that there is not the slightest advantage in high voltage, except that it permits the administration of a considerably larger dose at a distance of 4 to 6 inches beneath the skin than do the lower voltages. But that this dose exceeds by 20 per cent that obtainable at 200 kv. is doubtful, and the use of an inceased number of portals with 200 kv. permits us at present to deliver a dose destructive of a certain number of radiosensitive tumors without serious damage to the patient. In other words, we must remember that the wave length, which is directly correlated with the voltage, is not a factor in the destruction of the cells inasmuch as this destruction is entirely produced by the secondary beta rays which are derived from the roentgen rays when they tear off the electrons from the atoms which compose the tissues. It is folly, therefore, to treat superficial lesions with high voltages. Another important point which has been brought out is that patients seem to bear high voltage exposure without any more radiation sickness than occurs at the lower voltages.

A third point to be remembered is that the measurement of very high voltage roentgen radiation in terms of roentgens is at present impossible with any degree of accuracy, as it is impossible to measure voltages approximating 1,000,000 by spark gap methods within a considerable percentage of error. Accurate current measurements meet with the same difficulty and, as has been said, the roentgen measurements are inaccurate. This is especially true of the thimble chamber, for the standard roentgen open chamber fails considerably and the thimble chamber, as can be seen from the discussion in scientific journals, still gives very erroneous results. We are therefore still in the position that we were before the development of roentgen measurements, dependent upon exposures of patients to determine our possible dosages. This necessitates extreme caution in the use of such very hard radiation, as is shown by a recent paper by von Schubert.* He obtained some very serious reactions after massive doses and concludes that his results were not much better than with 200 kv. Some of the experiences of others who have read papers this afternoon point in the same direction.

* *Strahlentherapie*, 1934, *51*, 271

More study should be given to the effects of small exposures of 200 r per day, at low rates of administration, say not over 2 to 3 r per minute. The tendency has been because of lack of severe skin damage to give doses of 200, 300 or 400 r fairly rapidly in about fifteen minutes. This is contrary to the principles laid down by Coutard and is due obviously to the small number of portals which most of the large machines have and the large numbers of patients who have to be treated. But if we are going to imitate the good effects of the radium pack, and without question these papers point to the abandonment of the pack as a source of energy because at 1,000 kv. the wave length of the radiation is approximately equivalent to that of radium, the time of exposure to the roentgen rays must be adjusted so as to approximate that used by the pack, in which case the biological effects will be the same.

There has been much talk of a modified Coutard method, but it would be well if we used Coutard's methods according to the rules which he has laid down and which are based upon long experience with a large material, rather than to attempt some hasty modification which is only a return to the old intensive dosage system.

The papers indicate clearly that there are only a few types of neoplasms which are apparently more effectively treated with high voltages and in my opinion it would be well to confine the construction and operation of these very expensive forms of apparatus to those now installed in the institutions in various parts of the country and to wait until definite evidence is produced that much better results can be obtained with high voltages than greatly prolonged treatments at much lower potentials with apparatus at a fraction of the cost of these great installations. By multiplying the numbers of our machines instead of increasing the size of one machine we may be able to treat the same number of patients or even more and by the use of multiple portals obtain just as satisfactory results, as seem to be indicated by the reports read.

Dr. Lauriston S. Taylor, Washington, D. C. I would like to ask one or two questions of Dr. Ruggles. I would like to know what the

basis of his statement is, when he speaks of a kilovoltage of 750. I would also like to ask if it isn't unfair in comparing the dose received at 800 kv. to that at 200 kv. to use a 20 cm. depth. I believe you would find the difference more marked at 20 than at 10. While I am not familiar with clinical conditions, I think 10 cm. depth is more useful to the clinician.

In this connection, I want to say a word about nomenclature. The question has been raised at several different meetings here. The term "superhigh voltage radiation" has been used at times. There is nothing particularly wrong with that. It just happened that at the last meeting of the International Committee on Radiological Units, they agreed to use, in expressing the hardness of radiation, the term "hard radiation" for that radiation from 140 to 250 kv., and for superhigh voltage radiations, the term "superhard radiation."

In the same connection, the voltage designation was decided upon, tentatively at least, as *high voltage radiation* in the first case and *supervoltage radiation*, not superhigh voltage radiation.

I merely mention that in order that, as the literature on this subject increases, we don't burden ourselves with a number of different names for the same thing.

DR. CHARLES L. MARTIN, Dallas, Texas. I came to this session hoping to determine whether or not 800 kv. therapy is definitely superior to 200 kv. therapy, and I must admit that I am still somewhat at sea. Wave length, intensity, and time, are the only variables used in therapy. If those essayists, who attempt to demonstrate the superiority of supervoltage apparatus, would, in every instance, be careful to show results obtained with the same intensity and time intervals of treatment, varying only the voltage used, the information presented would be much more convincing. Too often cases treated with low intensities over long periods of time with multiple doses at 800 kv. are compared with those treated by the old single massive dose technique at 200 kv. I am still of the opinion that the selection of the proper intensities and proper time intervals of treatment will eventually prove to be more important than the use of excessive voltages, but my mind is open to conviction.

DR. LEUCUTIA (closing). I appreciate the discussion of Dr. Francis Carter Wood. I have a great admiration for the brilliancy with which he expresses himself. Of course, it is too soon to claim anything in the way of definite results. It was not the intention of the paper. The purpose was to merely point out the facts in a certain restricted number of cases which probably would amount, as they come to us at the present time, to about 30 per cent of all the cases in which this supervoltage therapy has decided advantage.

If, for example, a patient has carcinoma of the breast, with metastasis to the skeleton, the 200 kv., will produce sufficient palliation so that it will not be necessary to increase the voltage. The cases are carefully selected and only those subjected to this type of radiation in which there is a fair chance that the malignant lesion has remained localized to the volume irradiated. When the lesion has spread beyond that, then supervoltage therapy will have no advantage.

On the other hand, certain results have been obtained with the 200,000 technique. The supervoltage therapy will do nothing more than increase that percentage. Take, for example, carcinoma of the cervix: we have compared the results obtained thirteen years ago, seven years ago and at the present time, for a period of three years. There is no doubt that the results for three years have been improved. The average five year survivals of carcinoma of the cervix in our institution did not amount to more than 15 per cent; we believe on the basis of the comparison of the three year results that they will be increased to something over 30 per cent. So this is some accomplishment, although not a very great one if one considers the cancer problem as a whole.

DR. RUGGLES (closing). I want to thank Dr. Wood and the other men who discussed the paper. In regard to Dr. Taylor's question, the effective voltage was determined by the half-value layer in water after filtration through lead. A 20 cm. depth dose was used because that was the thickness of two or three patients we were treating at the time the measurements were made. We were concerned with figures from patients rather than from phantoms.

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# THE RELEASE OF ULTRAVIOLET RADIATION FROM ROENTGENIZED SUBSTANCES BY VISIBLE LIGHT*

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VISIBLE and ultraviolet fluorescence and phosphorescence play an important rôle in roentgen diagnosis, and practical use of these phenomena is being made in fluorescent and intensifying screens. Since we recently observed a fluorescent effect which may be of importance in the production of biological effects by roentgen rays or gamma rays of radium, we felt that it might be of interest to present the observation to this Society.

The visible fluorescence of various compounds under the influence of roentgen or gamma rays has been the subject of numerous studies. The persistence of both visible and ultraviolet luminescence after the removal of the compounds from primary radiation has also often been investigated, but the data obtained, notably in regard to ultraviolet phosphorescence, are meager.

In 1923, Perrine[1] demonstrated that when a series of compounds were under the influence of roentgen radiation, they fluoresced in the ultraviolet region. Perrine studied the emitted ultraviolet bands by photographing the spectrum with a Fuess single prism spectrograph. In 1934, by means of a spectral photon counter, Kudrjawzewa[2] investigated the ultraviolet fluorescence of roentgenized rock salt crystals under the influence of visible light. Her investigations were not extended to compounds other than rock salt crystals and no data were given on the presence of the ultraviolet phosphorescence in the dark or on the duration of persistent phosphorescence after removal of the salt from the primary irradiators.

Upon investigating some of the phenomena of artificial radioactivity with a Geiger photoelectric counter which was especially sensitized for ultraviolet radiation, we observed that the ultraviolet phosphorescence of certain salts, following their exposure to and removal from roentgen or gamma radiation, persists for unexpectedly long times; we noticed especially, however, *that this ultraviolet phosphorescence is conspicuously increased at any time if the irradiated compounds be exposed to visible light.* Of thirty-five compounds which we have examined thus far, pure sodium chloride, potassium chloride, sodium bromide, potassium iodide, rock salt and fluor spar crystals show this effect. Traces of impurities inhibit the effect. As an example, sodium chloride in the form of ordinary table salt shows no measurable ultraviolet phosphorescence after primary irradiation, while Merck's blue label reagent sodium chloride shows only a small effect. After a few recrystallizations of table salt, a strong ultraviolet phosphorescence appears. Heating the irradiated compounds momentarily increases the effect, which disappears, however, with further increase in temperature. Dissolving the compounds in distilled water completely inhibits the effect, but it is maintained if the salts are suspended in oils.

The Geiger-Mueller counter tube which we used is equipped with a cylindrical cadmium electrode and a quartz window. It is built upon the principle which we demonstrated before the American Association for the Advancement of Science at its meeting held in Cleveland in December, 1930. We believe that the sensitivity of the counter is in the neighborhood of 1000 quanta per cm.$^2$ per sec. for a wave length of 2536 Å.

Small quantities of the salts were exposed to radon or roentgen rays for periods ranging from a few seconds to several

* Read at the Thirty-sixth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 24–27, 1935.

hours. A few particles of the salt thus irradiated are sufficient to cause an increase in the discharges of the counter. These discharges are completely stopped when a thin glass plate, 0.2 mm. thick, is interposed between the material and the quartz window; control readings were obtained with this glass plate in place. The number of discharges in the counter beyond the dark count depends upon the purity of the salt, the intensity and duration of the primary radiation, the time which has elapsed since the primary radiation and, finally, the amount of visible light which has fallen upon the irradiated compound.

Sodium chloride has been used in most of our experiments since this compound can be easily purified, and shows by far the strongest ultraviolet phosphorescence. For identical experimental conditions, the relative number of counts in the Geiger counter for irradiated salts was found to be as follows: NaCl: KCl: NaBr: KI equal 100:25:10:3. Samples of the purest sodium chloride which we could secure produced increased counter discharges after irradiation with radon for several hours, even when the salt was removed from the counter window to a distance of about 1 meter. The number of counts produced when the compound was placed 3.5 meters from the counter window and illuminated with a light of 3 candle power at 10 cm. distance, was equal to that produced by the salt without visible light at a distance of 1 meter. Illumination with visible light produced thus a tenfold increase in the effect. On the other hand, samples irradiated for only a few seconds require the stimulus of visible light before their acquired property of ultraviolet phosphorescence becomes demonstrable with the counter.

In the case of sodium chloride, the released ultraviolet phosphorescence is strong enough to be measured spectrographically by means of a quartz monochromator. In agreement with Kudrjawzewa's results, we found a definite maximum of emitted ultraviolet radiation at about 2450 Å, but we have not yet determined the total spectral distribution. Also no satisfactory data regarding the spectral distribution of the ultraviolet phosphorescence of the other salts mentioned above have as yet been secured.

The ultraviolet phosphorescence which follows primary gamma or roentgen irradiation undergoes decay. Decay curves for various conditions of primary radiation and subsequent light treatment were obtained. The half life of the induced ultraviolet phosphorescence ranges from a few minutes to several months depending upon the type of salt, its purity, the intensity and duration of the primary radiation. Continuous illumination with visible light shortens the duration of the phosphorescence but certain recovery periods were observed after the illumination ceased.

Other observations, such as changes in the appearance of lag in the response of the ultraviolet phosphorescence to visible light, effect of the purity of the compounds upon the intensity and quality of the emitted radiation, dependence of the ultraviolet phosphorescence upon the various bands of the visible spectrum, etc., are in progress.

Wood[3] has described a phenomenon similar to that demonstrated in our experiment but which occurs in another part of the spectrum. Luminescent substances, such as luminous paints after exposure to ordinary light, give off radiant energy more rapidly if illuminated by infra-red radiation. This similarity between effects occurring in two separate parts of the electromagnetic spectrum point to the possibility that these phenomena may perhaps be observed in a still wider range of the spectrum. If this is the case, it might become of significance in radiation therapy.

## REFERENCES

1. PERRINE, J. O. A spectrographic study of ultraviolet fluorescence excited by x-rays. *Phys. Rev.*, 1923, *22*, 48–57.
2. KUDRJAWZEWA, W. Über die ultraviolette Fluorescenz der röntgenisierten Steinsalzkristalle. *Ztschr. f. Physik.*, 1934, *90*, 489–503.
3. WOOD, R. W. Physical Optics. The Macmillan Company, New York, 1923.

DISCUSSION

Dr. Lauriston S. Taylor, Washington, D. C. The effect that Dr. Glasser has just indicated is very interesting and opens a number of speculations. I would hate to say myself just what connection all this may have with biological reactions. There is, however, a well-known fact that wherever you have phosphorescence of a material, it indicates stored energy. If you irradiate a material and after the irradiation is over light is given off, it means that energy is stored. You can't get light for nothing. It immediately raises the question as to why, when you irradiate sodium chloride within the body, you could not follow it up with an irradiation of infra-red and thereby release in a shorter length of time this energy stored up in the sodium dissolved in the body. It is probably a very wild suggestion but nevertheless this whole work opens up such possibilities as that.

You might conceive, for example, irradiating the body, storing up energy in sodium chloride and various other chemical constituents of the body and get one effect without the light because the energy is just given up very gradually, and on the other hand, enhancing the effect considerably by exposing it to infra-red.

This paper brought to my mind an interesting case that happened a few years ago that might have some connection with this. A graduate student at Princeton used to give lectures to the freshmen. One of the lecture experiments consisted of demonstrating the bones in the hands by means of the x-ray and the fluorescent screen. He also demonstrated some of the variations in a very high frequency oscillator of the type Dr. Whitney, of the General Electric Company, developed not long ago. He would put his hands between the plates of the oscillator and note the change in temperature of the hand. It happened that this man received an exceedingly severe radiation burn on his hand. When afterwards they tried to check up on the dosage, it seemed to be below any possible tolerance limit. The question might be raised, in view of Dr. Glasser's paper, as to whether the radiation in the form of high frequency radiation brought about a sudden release of energy stored in the hand—released it so suddenly that the biological effect was greatly speeded up and resulted in a burn.

I mention these two or three things by way of pointing out the implications of this work.

Dr. Glasser (closing). In reply to Dr. Taylor's discussion, I wish to say that one of the first things we did to test a possible practical value of the salts was to dissolve them in water. Unfortunately, the effect then disappears completely. This shows that the effect is inherent in the crystal structure and for this reason it is difficult to use the effect in the manner suggested by Dr. Taylor. It is, however, possible to preserve the crystals in some other liquids and at the present time we are making experiments along that line.

The occurrence at Princeton which Dr. Taylor spoke about is very interesting and may have some relationship to our observations. Dr. Wood, of Baltimore, made similar observations on luminous paints. Certain luminous paints continue to emit light after they have been exposed for some time to visible light, and when they are then exposed to infra-red, the visible light emission is considerably increased. Such experiments point to the possibility that these effects are not limited to one part of the spectrum only but may occur over the whole range. We are also working along that line. We have studied with a spectrometer the influence of different parts of the visible spectrum upon the ultraviolet emission and have found that there seems to be maximum effect in the yellow-green.

# ROENTGEN CINEMATOGRAPHY

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COMPARATIVELY soon after the discovery of the roentgen rays—as early as 1896—the first experiments for the realization of roentgen motion pictures were undertaken. At that time two methods were attempted by MacIntyre: first, the production of film rolls by splicing single exposures to each other (direct method), and secondly, cinematography of the image on the fluorescent screen (indirect method). Thereafter numerous experimenters (in America chiefly Cole and Jarre) were occupied with the same problem.

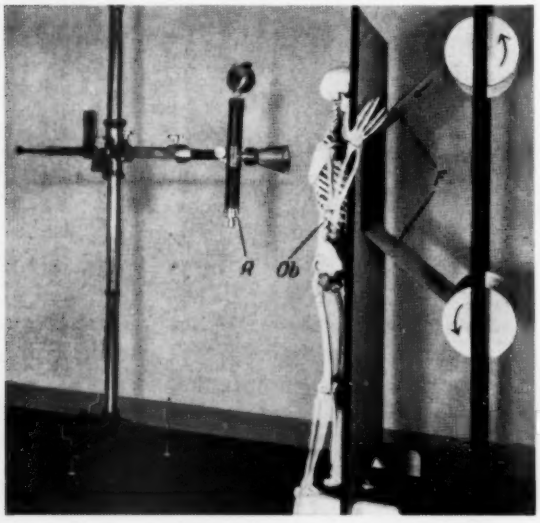


FIG. 1*a*. Schematic arrangement for direct cinematography. *R*. Roentgen tube. *Ob*. Object to be filmed. *F*. Film. (From *Deutsche Ztschr. f. Chir.*, 1933, *240*, 52.)

FIG. 1*b*. Schematic arrangement for indirect cinematography. *R*. Roentgen tube. *Ob*. Object to be filmed. *S*. Fluorescent screen with image. *C*. Photographic camera.

In the following pages, we shall report the results obtained by us after several years' work on roentgen cinematography.

First the direct method was employed (see Fig. 1*a*). Since in this method, the size of the single picture and that of the object must correspond, it was necessary, for financial reasons, to choose *small* animals, such as guinea pigs, as subjects for study. The apparatus built for this purpose had a picture frame of 24 mm. width and 36 mm. length. By means of a suitable pull-down device roentgen motion pictures of the thorax of a mouse or of the stomach of a guinea pig were obtained at the rate of 22 exposures per second. With this method, a film was prepared showing changes of normal peristalsis of the stomach and the duodenum produced by various stimulants (injection of hypophysin, neohormonal, morphium, pain irritation, etc.). A demonstration of this film was made during the X-ray Congress, Berlin, 1930.[1]

Films were also produced by means of the indirect method (see Fig. 1*b*). In this method, the image of a moving object reproduced on the fluorescent screen is photographed with a suitable apparatus. Animal films of comparatively long duration, up to half an hour, and even slow motion pictures of animal hearts (up to 100 exposures per second) could be obtained.

When sufficient experience had been

[1] See records of the Röntgengesellschaft, Vol. *21*, p. 52 and also *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1931, *44*, 658.

acquired from numerous experimental animal films, the method was applied to the study of the internal organs of the human body. We succeeded in reproducing the movements of the heart, of the lungs, of the diaphragm, of the esophagus (deglutition), of the stomach, and of the intestines all in their different functions. Whereas for the thorax in some cases 17 exposures per second were made, a smaller number (about 4) was considered sufficient for the stomach and the intestines. The reasons for this was that, even with such a limitation, an extremely high intensity of the roentgen rays was necessary; at present we reach the skin erythema dose in forty-nine seconds for exposures of stomach and intestines.

During our many years of work on this problem, every single item used in the production of the film has been brought to its highest efficiency. For instance, all the available (including American) fluorescent and intensifying screens were tested for their suitability in roentgen cinematography.

The fluorescent screen of the firm Schering-Kahlbaum A. G., Berlin, has proved to the most suitable one for our purposes. Excellent results were obtained with the roentgen tubes from C. H. F. Müller, Hamburg. All animal films taken up to now have been made with one of these two tubes. The special tube used for human exposures proved very efficient.

In the beginning of the experiments an old Pathé camera, altered to suit our purposes, was used and occasionally an apparatus of our own was employed, which, by means of a shortened time of movement, could operate without a diaphragm. More recently the Askania Werke have brought out a special X-ray Cine-Camera which, in accordance with my request, is equipped with an especially large sector opening in the rotating shutter. Owing to the fact that it works with a reliable precision, it undoubtedly represents considerable progress in the production of roentgen-ray motion pictures.

Considerable difficulty was encountered in procuring a suitable lens. For a long time we had to manage with a Zeiss Biotar f. 1. 4, but finally we succeeded in obtaining, one shortly after the other, a lens from the Rüo Werke, Berlin, with f. 1.0, one from the Zeiss Werke with f. 0.99, and finally a lens of f. 0.85.

Of the films which we used for our experiments, some were sensitized by us, some were Kodak Super Sensitive, and some were the usual special X-ray emulsion which therefore showed especially good gradation (Schleussner, Frankfurt a. M. Agfa, Berlin).

Whatever success we have achieved in roentgen cinematography was made possible because the firms mentioned above cooperated with us. We acknowledge this help with appreciation.

Considerable technical experience was necessary for the production of the films. Developing, printing, editing, and splicing were done in our own institute. Much of the printing was done by a machine of our own construction which enabled us to print from each negative frame two positive frames, one after the other. Thus, in spite of the limited number of exposures per second, a rather good demonstration becomes possible without any acceleration in speed of projection.

A description of the technical equipment follows. Owing to recent developments, the previous articles[2,3] have been superseded.

The outfit for the direct method of producing roentgen-ray motion pictures has already been described[1] and is very simple. The picture frame measures, as mentioned above, 24×36 mm.

Unfortunately, it was not possible to use the American film of double width, as intended, for in Germany a special perforating machine would have had to be built.

The pull-down device was similar to the usual types with the exception that the frame was twice the normal length. The film used was one made specially by the

[2] Janker, R. *Deutsche Ztschr. f. Chir.*, 1931, *232*, 570.
[3] Janker, R. *Deutsche med. Wchnschr.*, 1932, *58*, 1094.

firm of Schleussner. Both sides were coated with the emulsion generally used for the Doneo film.

By means of a specially built printing apparatus, however, the frame could be reduced to the normal size, so that the demonstration with normal projectors was made possible.

At first, intensifying screens were not used. However a design was worked out

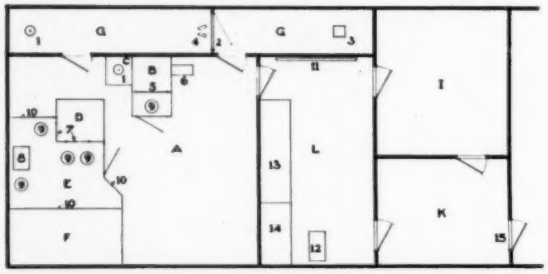

FIG. 2. *A*. Room for photographing roentgen films. *F*. Rebuilt Radio-Silex Apparatus of Koch and Sterzel, Dresden; used for connection to the working spaces *B*, *D*, and *G*. *E*. Cabin for observation and switching, enclosed by a heavy lead protection. 10. Lead-protection. 9. Seats for the observer and the operator. 8. Switchboard. 7. Window of lead glass plate for observation. *C*. Lead case for the roentgen tube (*1*) in the space used to make roentgen motion pictures of patients. *B*. Cabin for the patient for making roentgen films and roentgen sound films eventually with combination of the synchronous recording of electrocardiograms. 5. Window of lead glass for an observer (9). 6. Apparatus for filming and recording. *D*. Experimental working place for making roentgen motion pictures of animals. *L*. Lead-protected room for the sound recorder (13), the electrocardiograph (14), etc., also used as room for demonstrating roentgen films and roentgen sound films. 12. Projecting apparatus. 11. Projecting screen. *I*. Work shop. *K*. Micro-cinematographic room. 15. Entrance and passage to the developing and drying rooms in another part of the building. *G*. Room for indirect total exposures. 1. Roentgen tube. 2. Fluorescent screen for total exposures. 3. Camera. 4. Stand for the patient.

(D.R.P. 568 325) by which, by means of two endless intensifying screens pressing against the film, co-movement of the screens with the films could be obtained, and thus the effect of the after-glow of the screens on the film could be utilized. (For financial reasons an apparatus for the larger sizes of frames was not constructed.) The apparatus for exposing the films could also be used for projecting them by attaching a lens and adding a source of light. (For particulars see footnote No. 1.)

The indirect method of producing motion pictures was developed from a very simple beginning. After many a disappointment through wrong and round-about courses the following equipments are now at our disposal (see Fig. 2).

For the generation of roentgen rays an altered Radio-Silex-Apparatus of Koch and Sterzel (see *F* of Fig. 2) is used. For human beings we work with 125 kv. (peak) voltage and 50 ma., for animals with 100 kv. (peak) and 25 ma. In front of the apparatus stands a switch-case *E*, containing the switchboard and a number of instruments needed for operating on animals, and offering room for the attending staff and several observers. Directly in front of this switch-case is the space *D* for experimental work on animals, arranged as follows: On a horizontal table a holder for the animal is fastened which can be moved and turned in every direction. On the lower side of the plate of the table there is a fluorescent screen, the luminous surface downwards. From below, the image on the screen is photographed. It can be observed and the exposure of the film controlled from the switch-case.

By moving a lever the picture frequency can be increased to 100 exposures per second (slow motion pictures) and decreased to one exposure per second instead of the normal number of exposures of 16 pictures per second. It is not necessary to go into particulars with regard to the importance and value of decreasing and increasing the speed in order to catch the most characteristic moments and to make the most of the film.

Not only the space for animal experiments but also the equipment for human exposures can be electrically connected to the same outfit (*F*). The Müller special tube used therewith is surrounded by a lead-case (*C*) of 5 mm. thickness. The elec-

tric bushings are insulated by lead-glass plates of the same degree of protection. The person experimented upon or the patient sits or stands in a booth (*B*) which has a small additional compartment to protect and separate the observer. Here it turned out that, in view of the high intensities of the roentgen rays and of the comparatively short distances, a lead protection of the thickness originally presumed to be right was not at all sufficient, and therefore the booth and the space for the observer are now protected on all sides by lead of about 12 mm. thickness.

In addition to the ordinary roentgen motion pictures of human beings, roentgen sound films were also made of the heart and other subjects. For this work, the cabin for human exposures was made soundproof. It is apparent that the roentgen-ray equipment proper, the cooling pump and the different motors necessary may easily cause difficulties in the operation of the sound equipment. These were prevented in the usual way. The recording was done in the adjoining room (*L*), also protected by lead. This room is also a projection room for ordinary roentgen and for roentgen sound films. For sake of completeness we would like to mention also that there is a specially constructed micro-cinematographic equipment in room (*K*) and a workshop in room (*J*). Equipment for developing, drying, and processing the films had to be removed to other parts of the Roentgen Department.

The following films have been made:

"Alterations of the normal peristalsis of the stomach and of the duodenum produced by various stimulants (injection of hypophysin, neohormonal, morphium; pain irritation, etc.)." (Röntgen Congress, Berlin, 1930).

"Various pictures on respiration" (Röntgen Congress, Baden-Baden, 1931).

"Effect on the position, shape and size of the heart caused by variation of pressure in the thorax." (Surgical Congress, Berlin, 1931).

"Examination of the heart by combined electrocardiography, roentgen cinematography, and ionometry" (with Jacobi and Schmitz). (Rhein. Westf. Ges. f. inn. Med., Cologne, June, 1931).

"Vomition" (Surgical Congress, Berlin 1931).

"Roentgen motion picture of the movements of the stomach and the intestines of an animal." (Deutsch. Physiol. Kongress, Bonn, 1931).

"Experimental roentgen cinematographic observations on circulation" (with Naegeli). (Surgical Congress, Berlin, 1931).

"Experimental roentgen cinematographic observations of embolism of the lungs of an animal" (with Naegeli). (Osnabrück, 1931).

"Demonstration of roentgen motion pictures on circulation in the thorax at variation of pressure" (with Naegeli). (Deutsche Ges. f. Kreislaufforschung, Tübingen, March 14, 1932).

"Movements of the colon." (Ges. f. Chir., Berlin; and Röntgen-Kongress, Dresden, 1932).

"Examples of roentgen motion pictures of human beings." (Niederrhein. Ges., Bonn, May 9, 1932).

"On roentgen films and simultaneous sound recording of internal movements of the body" (with Schmitz). (Niederrhein. Ges., Bonn, May 9, 1932).

"Deglutition and the human esophagus."

"The peristalsis of the human stomach and duodenum."

"Synopsis of roentgen motion pictures produced since 1929."

This film called "Synopsis of roentgen motion pictures since 1929," gives a good general view of the movements of the human intestines and internal organs and on the cinematographic study of a number of biological and physiological problems.

The accompanying illustrations (Figs. 3, 4 and 5) show a few single pictures taken from different films and slightly enlarged.

These roentgen films are useful not only for demonstration purposes, but they represent a means of research of considerable value, as is explained in a previous publication.[4] There are a number of ways of utilizing such a film. Taking the heart as an example, every single picture of the film had to be enlarged and measured. In a very simple way we succeeded in producing auxiliary equipment permitting this special work to be done automatically.

The possibility of combining the roentgen motion pictures with other methods is

[4] Janker, R. *Deutsche. Ztschr. f. Chir.*, 1933, *240*, 52.

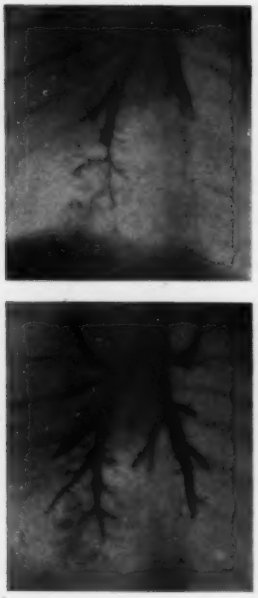

FIG. 3. Various studies on the filling of the bronchi of a cat.

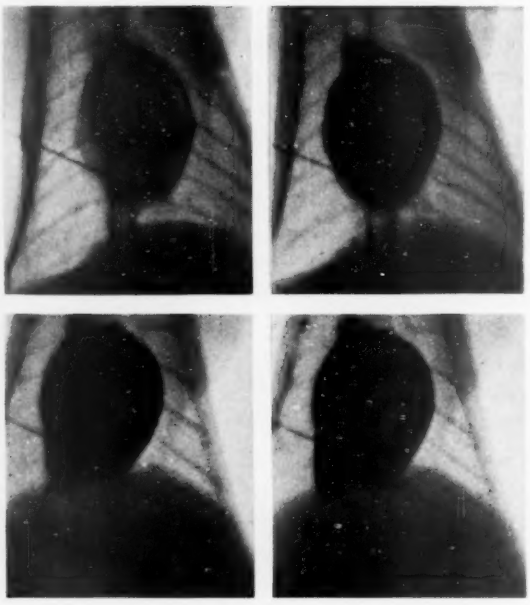

FIG. 4. Pericardial effusion affecting heart force. Injection of a contrast solution into the pericardium of a cat.

of special scientific value. It may be mentioned that, in 1932, the Zeitler-Studienhaus-Stiftung published the following prize-competition: "Entwicklung einer Apparatur für die kinematographische Bild- und Tonaufnahme von Vorgängen im Körperinnern." The author suggested that pictures of the intestines and internal organs, for instance of the heart, ought to be made by roentgen motion pictures and that at the same time records of the sounds of the heart ought to be made in exact synchronism. This could be done with the aid of one of the well known sound film procedures, for instance with records. The prize was given this solution some time ago, and

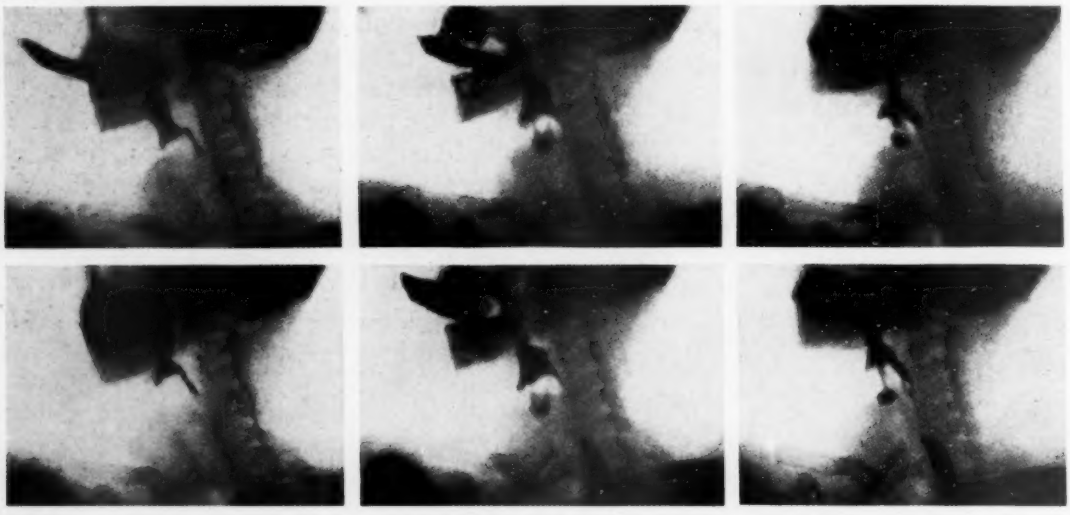

FIG. 5. Human deglutition (from *Deutsche Ztschr. f. Chir.*, 1933, *240*, 52).

when elaborating these proposals with Dr. W. Schmitz, the practical utilization of the process could be demonstrated.

In this connection we will mention the combination of roentgen-ray motion pictures with electrocardiography and ionography.[5]

Roentgen-ray motion pictures are primarily of scientific value. However they could already be utilized in a number of cases of difficult diagnosis. A separate report will be made on this subject.

*Supplement.* The experimental photography of the image on a fluorescent screen made it possible to work out a special process of making a roentgenogram of the entire body. Denis Mulder[6] in 1927 published "Total X-Photos." These excellent roentgenograms were taken with a single exposure at a great distance from the roentgen tube. These pictures, however, are too expensive for practical purposes, especially for examinations in series. The process developed by the writer brought about a change in this matter. Just as the fluorescent screen can be used cinematographically it must be possible to make, with corresponding sources of intensity, long-distance photographs of the image on the fluorescent screen, i.e. an indirect small photograph of the patient's entire body on the fluorescent screen. The firm of Kahlbaum-Schering, Berlin, made for us for this purpose a jointless fluorescent screen, measuring 210×90 cm. With the aid of the altered Radio-Silex Apparatus, described above, a sufficiently bright image of a whole person can be reproduced on the fluorescent screen from a distance of several meters. This image was photographed with a simple specially constructed camera fitted with a Zeiss R-Biotar, f. 0.85. With this camera only very small pictures, about Leica-size, were reproduced. Later on, therefore, it seemed advisable to choose a larger size, 6×9, or 9×12 cm. The best lens at our disposal for this size of the picture was a Zeiss Biotar f. 1.4 with a focal length of 14 cm.

The pictures are taken in a long small room (*G*). The roentgen rays produced by the tube (1) project an image of the patient (4) on the fluorescent screen (2), which image is photographed by the camera (3) in the way described. The fluorescent screen with its frame can be turned on hinges so that the patient may conveniently pass to the stand behind the screen.

Fig. 6. Example of total roentgenogram of a man.

Of special importance is the low cost of the process, especially for stereo total exposures, such as Hasselwander and Pratje require for anatomical, anthropological, and pathological-anatomical purposes. The transition from ordi-

[5] Jacobi, J., Janker, R., and Schmitz, W. *Deutsches Arch. f. klin. Med.*, *172*, 493.

[6] Mulder, Denis. Total X-Photos. Van Dorp & Co., The Hague, 1927.

nary indirect total exposures to stereoscopic ones was not difficult; only a mechanism for moving the tube the distance of the eyes and for interchanging the small film holders had to be constructed. There is also another fact which may be looked upon as a special advantage, i.e. the reduction of the pictures of direct total exposures for measuring purposes is no longer necessary. In addition, diapositives ready for reproduction are obtained at once.

If, however, direct total exposures be needed, for teaching or for demonstration purposes, they can be easily obtained with the aid of the arge fluorescent screen, measuring 210×90 cm.; the screen is then used as an intensifying screen and the frame of the screen as a holder for the photographic film or paper, which only has to be inserted. The developing of such exposures, however, necessitates experience and special equipment. In large flat trays, equalization of the effect of the naturally different exposures, for instance, of the pelvis and the hands, is attained by sponging with developers of different concentrations.

We shall report later on the various possibilities of application of exposures of the entire body. A reproduction of such a roentgenogram is shown in Figure 6.

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# FACTORS INFLUENCING THE QUANTITATIVE MEASUREMENT OF THE ROENTGEN-RAY ABSORPTION OF TOOTH SLABS*

## V. THEORY OF THE STEP TABLET

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IN A FOREGOING paper† (IV) the mass absorption coefficients of bone, dentine and enamel were calculated and, upon the basis of these theoretical relations, penetrometers were selected which were shown experimentally to be suitable for expressing interpolated absorption values. There is, however, the additional theoretical possibility of evaluating the mass absorption coefficients of bone, dentine and enamel by means of the actual absorptions measured densitometrically. In the following discussion, a simple theoretical connection will be essayed between (*a*) the intensities of the radiation falling on and transmitted by the tooth or other tissue, (*b*) the thickness of the tissue, (*c*) the mass absorption coefficient of the tissue, (*d*) the densities produced in the emulsion after a standard processing and (*f*) the gamma of the emulsion. In order to present the connection of these factors briefly and yet with sufficient detail to make their relations intelligible, simple statements of the equations of roentgen-ray absorption and of photographic density will be made. The relation between roentgen-ray absorption and film density will be offered, together with some indications as to its use in calculating (*a*) properties of the tissue (or filter) such as effective mass absorption coefficient, and (*b*) properties of roentgen rays such as effective wave length. The literature does not reveal any discussion of the theoretical connection of these concepts and because of its interest to us in our experimental work a broad review of these factors and their application to practical roentgen densitometry is outlined. It is hoped that the ideas expressed here will stimulate others to apply this procedure.

For simplification it is probably easiest to consider these subjects mathematically. For those who desire a full treatment of the two fields (roentgen-ray and photographic theory), the theoretical side of roentgen-ray absorption has been well reviewed recently in "Science of Radiology," edited by Glasser, published by Charles C Thomas, Springfield, Illinois (1933) and the theoretical background of photographic sensitometry is clearly and simply discussed in the excellent book of Neblette, "Photography," D. Van Nostrand, N.Y. (1927).

If one considers a light source, a negative and a contact print, a complete analogy exists between this arrangement and the roentgen-ray tube, the filters and tissues and the roentgenogram. The difference lies in the physical properties of the radiation or conversely, the structure of the substances or tissues which will transmit over certain wave length ranges. By definition in photographic parlance, "correct exposure" is that one which produces in the emulsion the same ratio of densities which the "brightnesses" of the photographed objects originally possessed. The limits for a "correct roentgenogram" will be stated in a later paper, for the discussion to follow it is sufficient to point out the close connection between the theory of photographic reproduction and the theory of the roentgen-ray penetrometer.

By combining the classical equation for

† Hodge, H. C., Bale, W. F., Warren, S. L., and Van Huysen, G. Factors influencing the quantitative measurement of the roentgen-ray absorption of tooth slabs. IV. Absorption of coefficient factors. Am. J. Roentgenol. & Rad. Therapy, 1935, *34*, 817–838.

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roentgen-ray absorption:

$$\ln \frac{I_0}{I} = \mu x$$

where $I_0$ = initial intensity of beam, a function of the wave length
$I$ = transmitted intensity
ln = natural logarithm
$\mu$ = linear absorption coefficient of tissue
$x$ = thickness (cm.) of tissue

with the two equations of photographic sensitometry

$$It = E$$

where $I$ = intensity of radiation striking emulsion expressed in units reciprocal with time units
$t$ = time
$E$ = photographic exposure
$d = \Gamma \ln E + C$
where $d$ = photographic density
$\Gamma$ = gamma of emulsion (natural logarithms)
$C$ = constant of integration

it is obvious that a fourth equation may be written connecting the photographic densities and gamma of the emulsion with the beam equalities, $I_0$ and $I$, and also with filter properties $\mu$ and $x$ as follows:

$$\ln \frac{I_{film}}{I_{tissue}} = \frac{1}{\Gamma}(d_{film} - d_{tissue}) = \mu_{tissue}\, x_{tissue} \qquad (1)$$

where $I_{film}$ = intensity of unfiltered beam striking emulsion
$I_{tissue}$ = intensity of beam after traversing tissue
$d_{film}$, $d_{tissue}$ = densities of film not under tissue and under tissue, respectively.

Applied to a penetrometer (step tablet), there are two additional equations of much the same form that may be added as follows:

$$\ln \frac{I_1}{I_2} = \frac{1}{\Gamma}(d_1 - d_2) = \mu(x_2 - x_1) \qquad (2)$$

where the subscripts 1 and 2 refer to two steps of the penetrometer. Specifically it is found most useful to compare step 1 of our penetrometer (0.025 cm. Al) with the other seven steps which may be done by specializing the above equation as follows:

$$\ln \frac{I_1}{I_{2,3,4,etc.}} = \frac{1}{\Gamma}(d_1 - d_{2,3,4,etc.}) = \mu(x_{2,3,4,etc.} - x_1). \qquad (3)$$

In the foregoing equations, there are some tacit assumptions that have limited applications; these should be pointed out. In the equation of roentgen-ray absorption, the $I_0$ and $I$ are intensities whose ratio will depend, for a given filter, not only on the thickness but also on the wave lengths. For monochromatic radiation, the substitution of $I$ in the Roscoe-Bunsen equation, $It = E$, is a valid procedure. But for white radiation such as we use, the "I"s are not identical, the $I$ of the Roscoe-Bunsen equation being interpretable as a time factor for a given wave length. Therefore, equation (1) as stated is strictly applicable only to monochromatic radiation and probably would not be a true equation even at a stated kilovoltage if different tube-machine combinations were used.

Another limit which must be mentioned is the "correct exposure" limit for the emulsion. The density is a linear function of the logarithm of the exposure only in certain density ranges, ranges typical of the emulsion (see Fig. 40 and also later paper).

To open the discussion of equation (1), let us point out a few of the factors which influence the image density produced under a filter exposed to roentgen radiation as follows:

1. radiation factors . . . . quality of beam, homogeneity, etc.
2. filter factors . . . . . thickness, absorption coefficient, etc.
3. film factors . . . . . grain size, emulsion thickness, etc.

4. exposure factors.....time of exposure, distance from tube, etc.
5. processing factors...time of development, temperature, etc.

The simplicity of the equation given above is ample evidence that most of these factors are not accounted for. Moreover, it is impossible to say quantitatively in what fashion most of these factors influence the density. Where does the equation apply then? It applies to duplitized roentgen-ray film which is lead-backed and wrapped in black paper (not in cardboard cassettes), is exposed to "white" radiation from a round focus tube (Tungsten target) at 30 kv. (instrument board) 30 ma., 15–30 inches target-film distance for times of 0.75 to 10 seconds depending upon the distance and is developed in fresh Eastman X-Ray developer for 5 minutes at 65° F., with constant agitation finally to give film densities of 2 to 3.5 Whether or not the equation will apply outside these stringently held conditions can only be ascertained by experimental tests.

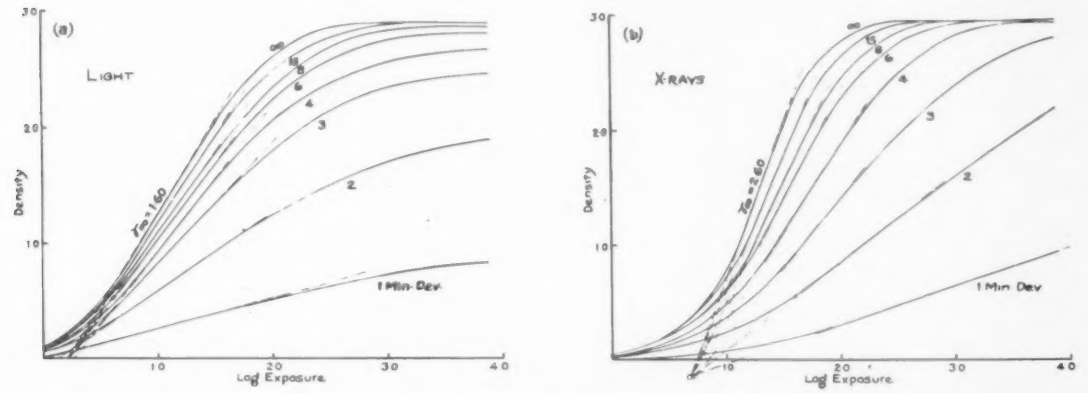


Fig. 40. "Characteristic curves, for positive film, smoothed and corrected for fog." Courtesy of R. B. Wilsey and taken by permission of the publishers from the paper of Wilsey and Pritchard, "A comparison of x-ray and white light exposure in photographic sensitometry" from the *J. Optic. Soc. Amer.*, 1926, *12*, 661. (This figure includes parts *a* and *b* of Fig. 3, page 666.) As may be seen, the form of the characteristic curve does not depend on the radiation but the numerical slope differs as a function of the abscissae. The exposure units for the "light" curves are in candle-meter-seconds, the exposure units for the "x-ray" curves are arbitrarily chosen.

Of what value can an equation be which is so strictly limited in its application? In the first place, if true under the conditions of our experiments, it may be used to calculate the properties of tissues as filter, i.e., the absorption coefficients. In the second place, if it is true at the stated conditions, it may be used to calculate any one unknown factor; for instance, if the film exposed to unfiltered radiation is too dense to read by the Capstaff-Purdy densitometer (limit of 2.8 density units) the film density may be calculated, other factors being known. In the third place, the effective wave length of the radiation may be obtained by interpolation, thus permitting a statement of quality of roentgen radiation from photographic measurements. In the fourth place, it may be used to calculate the gamma of the film, knowing only the thickness of the filter and its absorption coefficient. These indicated uses of the equation would justify its statement, if true.

The testing of an equation may become very laborious if each factor entered is varied separately. It will be sufficient for our purpose to show the approximate limits of the quantitative nature of the equation by simply varying the film density and observing whether or not the predicted constancy of difference, $d_{film} - d_{step\ 1}$, is obtained.

In Table LV are given the average D.Rs. in 32 films whose densities vary from 2.12

to 3.49; the average D.Rs. in Step 1 varying from 1.46 to 2.76 in the same films. The average D.Rs. were obtained from at least four readings spaced carefully so as to obtain information from each part of the film or step. The D.Rs. marked with an asterisk were read on the Jones High Density Densitometer in the Research Laboratory of Kodak Park through the courtesy of Dr. L. A. Jones.

TABLE LV

| Film No. | Average D.R. in Film | Average D.R. in Step 1 | $D_f - D_1$ |
|---|---|---|---|
| E1535 | 2.53 | 1.77 | 0.76 |
| E1635 | 2.45 | 1.71 | 0.74 |
| E1735 | 2.66 | 1.81 | 0.85 |
| E1835 | 2.59 | 1.85 | 0.74 |
| E1935 | 2.67 | 1.90 | 0.77 |
| E2035 | 2.67 | 1.90 | 0.77 |
| E2135 | 2.54 | 1.79 | 0.75 |
| E2235 | 2.12 | 1.46 | 0.67 |
| E2235D | 2.71 | 1.94 | 0.77 |
| E2335 | 2.65 | 1.89 | 0.76 |
| E2435 | 2.61 | 1.85 | 0.76 |
| E2535 | 2.62 | 1.88 | 0.74 |
| E2835 | 2.58 | 1.77 | 0.81 |
| E2935 | 2.57 | 1.81 | 0.76 |
| S34E94 | 3.49* | 2.72 | 0.77 |
| S34E94D | 3.49* | 2.76 | 0.73 |
| S34E97 | 3.12* | 2.40 | 0.72 |
| S34E98 | 3.07* | 2.40 | 0.67 |
| S34E99 | 3.08* | 2.33 | 0.75 |
| S34E100 | 3.10* | 2.35 | 0.75 |
| S34E101 | 3.14* | 2.50 | 0.64 |
| S34E102 | 3.10* | 2.31 | 0.79 |
| S34E103 | 2.92* | 2.13 | 0.79 |
| S34E104 | 2.94* | 2.16 | 0.78 |
| S34E105 | 3.00* | 2.23 | 0.77 |
| S34E106 | 3.03* | 2.28 | 0.75 |
| S34E107 | 3.12* | 2.37 | 0.75 |
| S34E108 | 3.03* | 2.29 | 0.74 |
| S34E109 | 3.04* | 2.26 | 0.78 |
| S34E110 | 3.07* | 2.26 | 0.81 |
| S34E113 | 3.03* | 2.30 | 0.73 |
| S34E114 | 3.22* | 2.42 | 0.80 |

If the equation is true, there should be a constant difference between the D.Rs. in the film and in Step 1, respectively. It is evident from the column headed $D_f - D_1$ that there is a fair constancy. Although the extremes of difference are 0.64 and 0.85, most of the films are closely grouped around an average difference of 0.76, in fact 66 per cent of the films have differences of 0.74 to 0.79, inclusive. This represents a 7 per cent spread but when it is considered that the D.Rs. cannot be reproduced within 0.02 and that each difference figure represents at least two such readings, the range of 0.05 density units does not seem so great. Consequently, on the average and within the limits stated, the equation $\ln \frac{I_{film}}{I_{step\ 1}} = \frac{1}{\Gamma}(d_{film} - d_{step\ 1})$ may be said to be true.

After equation (1) had been developed and tested, we found that although not expressed in this form the equations of photographic sensitometry are essentially identical. It is easiest to grasp the identity by considering that this expression is the same that would be written to describe the intensities of light passing through two areas of a film of different absorbing characteristics (thus defining the "densities") as related to the densities of those areas, or as related to the densities produced in another emulsion exposed to the two different transmitted light intensities. In photographic sensitometry, the analogue of $\mu$ would be two factors, i.e., k, the absorption coefficient of the emulsion (principally attributable to the silver grains) and m, the concentration of absorbing particles. However, because equation (1) as written for roentgen radiation may be used to obtain several important data, we are offering it, not as a new theory, but as a useful application.

The most important application of the equation is to the problem of obtaining the absorption coefficients of enamel and of dentine. It will be shown that the equation gives values of the proper magnitude when their quantitative exactness is tested experimentally by the ionization method.

Before the $\mu_{Enamel}$ and $\mu_{Dentine}$ may be calculated, there is one term of the equation that must be given a numerical value, i.e., $\Gamma$, the gamma of the film (expressed in natural logarithms). Although

gamma is commonly expressed in terms of logarithms to the base 10 and the usual symbol is $\gamma$, we have chosen to calculate gamma in terms of natural logarithms and to express it by the symbol, $\Gamma$. The justification of this unusual procedure will be briefly attempted. The usual photographic practice is to plot densities vs. $\log_{10}$ exposure to obtain the "characteristic" or "H and D" curves (see Fig. 40). The "exposure" units along the abscissa in photographic sensitometry have been carefully defined in terms of candle meter seconds. In roentgen-ray studies, in general, each investigator has proposed his own exposure scale and has plotted densities vs. exposures and vs. logarithm exposures at his own convenience; thus in Figure 40 (*b*) the log 10 exposures plotted along the abscissa are in relative not absolute units.

The straight line portion of the characteristic curve is the only part in which simple mathematical relations hold between density increments and logarithm exposure increments. Consequently considerable importance is attached to this part of the curve. Its slope, or

$$\frac{\Delta \text{ density}}{\Delta \log \text{ exposure}},$$

is called gamma and is used to describe the film. In our roentgen-ray studies, for convenience in deriving the equation we have chosen to express the "characteristic" curves as density vs. $\ln_e$ Exposures. The "absorption by filter" equation is expressed in natural logarithms and it is easy to write equation (1) if the density—logarithm Exposure relations are similarly stated. However, it is obvious that the slope of a "density vs. $\log_{10}$ E" curve will be numerically equal to the slope of a "density vs. $\ln_e$ E" curve multiplied by the factor relating the two logarithms. Therefore, the $\Gamma$ of our equation is equal to the conventional gamma ($\gamma$) divided by 2.3.

From the data of Wilsey (see a later paper) the conventional value of gamma for duplitized roentgen-ray film is calculated using only density increments which

Table LVI

(data of Wilsey—see later paper)

| Minutes Development Time | $\text{Log}_{10}$E | Density | $\Delta^d$ | Gamma |
|---|---|---|---|---|
| 3 | 2.1 | 1.62 | | |
| | 2.4 | 2.22 | 0.60 | 2.0 |
| 4 | 1.8 | 1.48 | | |
| | 2.4 | 2.92 | 1.44 | 2.4 |
| 5 | 1.8 | 1.82 | | |
| | 2.1 | 2.62 | 0.80 | 2.7 |
| 6 | 1.8 | 1.99 | | |
| | 2.1 | 2.84 | 0.85 | 2.8 |
| 8 | 1.5 | 1.50 | | |
| | 1.8 | 2.21 | 0.71 | 2.3 |
| 10 | 1.5 | 1.58 | | |
| | 1.8 | 2.31 | 0.73 | 2.4 |
| 12 | 1.5 | 1.63 | | |
| | 1.8 | 2.36 | 0.73 | 2.4 |

are clearly in the "straight line portions" of the characteristic curves. The time of development, $\log_{10}$ E increments, density increments and gamma values are given in Table LVI. Gamma is seen to vary with development time as shown in Figure 41, a variation not greatly different than that

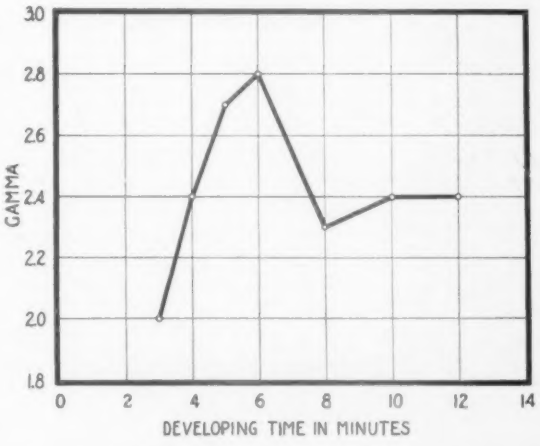


Fig. 41. Gamma values from the data of R. B. Wilsey (Table LVI) are plotted as ordinates against the development time in minutes. The variation up to about eight minutes is magnified, the range being only 0.2 above and below 2.4.

found for other emulsions, exposures and developers (see Jones, page 89; Wilsey and Pritchard, pages 665 and 666). At first glance there seems to be a tremendous variation in gamma with changing development time, but closer inspection of the ordinates will show that these units are greatly magnified and that the total change is not great. The average gamma for development times of four to eight minutes inclusive is 2.5. Thus, the density-log exposure equation as follows:

$$d = 2.5 \log_{10} E + C,$$ or using natural logarithms as follows:

$$d = 1.1 \ln_e E + C.$$

We have now obtained a value for $\Gamma = 1.1$ which permits the equation

$$\ln \frac{I_{film}}{I} = \frac{1}{\Gamma}(d_{film} - d) = \mu x$$ to be specialized for the calculation of $\mu_{Enamel}$ or $\mu_{Dentine}$. For example, if the former is to be found we may write

$$\ln \frac{I_{film}}{I_{Enamel}} = \frac{1}{\Gamma}(d_{film} - d_{Enamel}) = \mu_{Enamel} x_{Enamel}.$$

From the two right hand members of this tri-part equation, it is evident that if the $d_{film}$ and $d_{Enamel}$ are read, and the x enamel measured, $\mu$ enamel may be calculated.

One more concept must be added at this time although it will be elaborated and illustrated later. Since the equations of roentgen-ray absorption are all written for monochromatic radiation, and since we are using "white" radiation, the $\mu_s$ found by our work will be "*effective*" $\mu_s$. The effective $\mu$ may be described as the $\mu$ which would result if a monochromatic radiation were used whose intensity decrement on passing through the given filter thickness is identical with the intensity decrement found with "white" radiation. The usefulness of the effective $\mu$ concept is evident since in employing stated conditions, as we do, it permits us to characterize the filter. Once having obtained $\mu$ we may interpolate a similarly conceived "*effective*" *wave length* from the curves given in Figure 19 (see paper IV).

In order to obtain absorption coefficients for enamel and for dentine at more than one effective $\lambda$, the data (presented in full later) were taken from the experiment wherein 4 teeth were measured densitometrically at 4 thicknesses each, e.g., 1.20, 1.00, 0.80 and 0.60 mm., the tolerance in each case being $\pm 0.01$. mm. For simplicity (see Table LVII) the D.Rs. in the enamel and in the dentine of the 4 teeth are averaged at each thickness so that the $\mu_{effective}$ and other figures are averages for the tissues and not exact values for any tooth. The average density of the film was ob-

TABLE LVII

| Film No. | | A 43 | | A 44 | | A 45 | | A 46 | |
|---|---|---|---|---|---|---|---|---|---|
| Thickness of Tooth slabs | | 1.20 mm. | | 1.00 mm. | | 0.80 mm. | | 0.60 mm. | |
| Average D.R. in films | | 3.77 | | 3.96 | | 3.82 | | 3.87 | |
| | | *Enamel* | *Dentine* | *Enamel* | *Dentine* | *Enamel* | *Dentine* | *Enamel* | *Dentine* |
| Average D.R. in 4 teeth | | 0.64 | 1.10 | 0.97 | 1.69 | 0.95 | 1.68 | 1.37 | 2.13 |
| $d_f - d_{tissue}$ | | 3.13 | 2.67 | 2.99 | 2.32 | 2.87 | 2.14 | 2.50 | 1.74 |
| effective $\mu$ | | 23.8 | 20.3 | 27.2 | 21.2 | 32.6 | 24.4 | 37.9 | 26.5 |
| effective $\mu/\rho$ | | 7.9 | 6.8 | 9.1 | 7.1 | 10.9 | 8.1 | 12.6 | 8.8 |
| effective $\lambda$ | Instrument board | 0.72 | 0.76 | 0.73 | 0.78 | 0.75 | 0.79 | 0.77 | 0.81 |
| | Sphere gap | 0.69 | 0.72 | 0.70 | 0.73 | 0.71 | 0.74 | 0.73 | 0.77 |
| Average I.V. | | 1.7 | 1.1 | 1.5 | 0.9 | 1.3 | 0.8 | 1.0 | 0.6 |

tained by averaging a number of readings obtained through the courtesy of the Physics Department of the Research Laboratory of the Eastman Kodak Company, using the Jones High Density Densitometer. The effective $\mu_{enamel}$ and $\mu_{dentine}$ are 23.8 and 20.3 respectively for the 1.20 mm. sections; the values for each tissue increasing as the thickness decreases. To obtain mass absorption coefficients the effective $\mu$s are divided by the respective physical densities. At first the total or average densities of the tissues were used, i.e., $\rho_{enamel}$ equal to 3 (approx.) and $\rho_{dentine}$ equal to 2 (approx.). The $\mu/\rho$ obtained were of an allowable magnitude for the enamel, but for the dentine the coefficients became larger than those for enamel and thus absurd. Since the mineral constituent is responsible for most of the absorption in each tissue (see paper IV), the assumption was made that the mineral constituent in dentine has about the same physical density as the mineral constituent in the enamel. Using $\rho = 3$ for both enamel and dentine, the $\mu/\rho$ values are 7.9 for enamel and 6.8 for dentine at a thickness of 1.20 mm.; the values for both tissues increase with decreasing thickness. In order to plot the $\mu/\rho$ against wave length as has been done theoretically in Figure 19, paper IV, some $\lambda$ effective must be chosen for each thickness of each tissue. The only sound basis available seemed to be the $\lambda$ effective which could be obtained from the previously found (experimentally) $\lambda$-thickness curves for Al. Consequently, the comparable absorbing thickness of Al (average I.V.) was computed for each thickness of enamel and of dentine (see Table LVII) and the $\lambda$ effective values were interpolated from the curve in Figure 19. On this basis the values not only are of an allowable magnitude in both tissues but the coincidence with the theoretical curves (see Fig. 42) is almost amazing. This is additional evidence that the calculated physical densities ($\rho_{\text{calc. Enamel}} = 2.82$, $\rho_{\text{calc. dentine}} = 2.74$, see last page of paper IV) of the mineral constituents of enamel and of dentine are of approximately the correct magnitude.

The average interpolated values (See paper III d) for the enamel are 1.38 mm. Al at 20 kv., 1.36 mm. Al at 25 kv., 1.32 mm. Al at 32 kv., 1.40 mm. Al at 41 kv., 1.40 mm. Al at 51 kv., and 1.45 mm. Al at 61 kv. Thus, the average I.V. for enamel

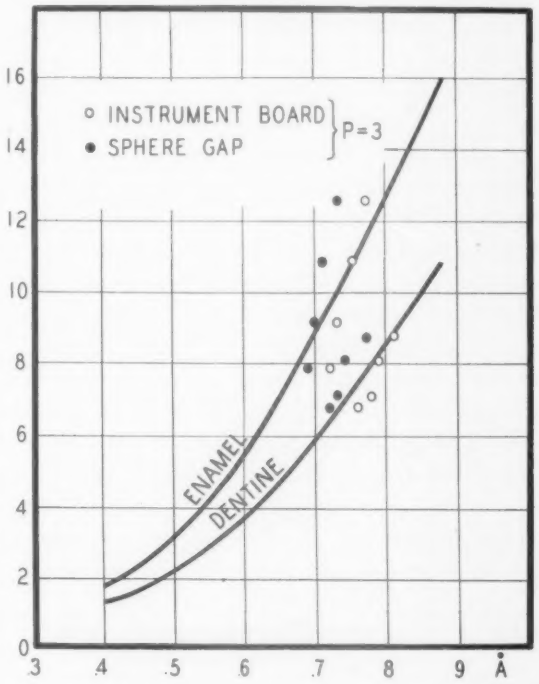


Fig. 42. Mass absorption coefficients are plotted as ordinates against the wave length in Ångströms. The smooth curves for enamel and dentine are taken from Figure 19, the values having been obtained from calculations based on a "best" chemical analysis for each tissue. The circles show that the mass absorption coefficients obtained densitometrically using equation (1) (assuming a density of the principal absorbing constituent of each tissue equal to 3) are placed close to the theoretical values.

tends to increase slightly with increasing kilovoltage; that this increase of I.V. may be theoretically predicted from the equation is shown in the following discussion.

The I.V. for the enamel may also be described as the millimeters of Al producing a density in the film exactly equivalent to the density under a given thickness of enamel when both are exposed to a roentgen-ray beam. Consequently the problem

of the interdependence of kilovoltage and I.V's. for enamel may be simply stated as follows: what is the thickness of Al giving a D.R. equal to the D.R. under a given thickness of enamel at 30 kv.? at 40 kv.? It may be seen above that the thickness of Al (I.V.) at 30 kv. is less than that required at 40 kv.; the same result is prophesied by equation (1). Let a thickness of Al, $x_{al}$ be so chosen that when a beam of roentgen rays at 30 kv. of intensity, $I_0$ strikes it, the intensity of the transmitted beam $I_{al}$ produces a density of $d_{al}$ in the film below. Let the given thickness of enamel, $x_{en}$ when radiated by the same beam transmit a beam of intensity, $I_{en}$, which produces a density of $d_{en}$ in the film. The roentgen-ray beam of intensity, $I_0$, produces a density of $d_0$ when it strikes the film unfiltered. Let the density under the Al, $d_{al}$ equal the density under the enamel $d_{en}$ at 30 kv., that is, $x_{al}$ = I.V. for enamel.

The relation between the beam intensities and the densities produced in a film is expressed by the equation $\ln \frac{I_0}{I} = \frac{1}{\Gamma}(d_0 - d)$. At 30 kv.:

Under the Al, the relation between intensities and density is as follows:

$$\ln \frac{I_0^{30}}{I_{al}^{30}} = \mu_{al}^{30} x_{al} = \frac{1}{\Gamma}(d_0^{30} - d_{al}^{30}).$$

$$\Gamma \mu_{al}^{30} x_{al} = d_0^{30} - d_{al}^{30}.$$

Under the enamel, the following relation holds:

$$\Gamma \mu_{en}^{30} x_{en} = d_0^{30} - d_{en}^{30}$$

By hypothesis:

$$d_{al}^{30} = d_{en}^{30}, \text{ therefore}$$

$$d_0^{30} - d_{al}^{30} = d_0^{30} - d_{en}^{30}$$

and $\Gamma \mu_{al}^{30} x_{al} = \Gamma \mu_{en}^{30} x_{en}$. From which relation by a simple rearrangement

$$\frac{\mu_{al}^{30}}{\mu_{en}^{30}} = \frac{x_{en}}{x_{al}} = K'.$$

Thus if the densities are equal under Al and enamel, for the thicknesses $x_{al}$ and $x_{en}$, then the ratio of $\mu_{al}^{30}$ to $\mu_{en}^{30}$ is equal to the ratio of the thicknesses $\frac{x_{en}}{x_{al}}$ which is a constant, K'.

At 40 kv.:

$$\ln \frac{I_0^{40}}{I_{al}^{40}} = \mu_{al}^{40} x_{al} = \frac{1}{\Gamma}(d_0^{40} - d_{al}^{40});$$

similarly for enamel.

In order that the interpolated value be constant: $d_{al}^{40}$ must $= d_{en}^{40}$. It follows that $d_0^{40} - d_{al}^{40}$ must $= d_0^{40} - d_{en}^{40}$ and

$$\frac{\mu_{al}^{40}}{\mu_{en}^{40}} = \frac{x_{en}}{x_{al}}$$

But since at 30 kv.:

$$\frac{\mu_{al}^{30}}{\mu_{en}^{30}} = \frac{x_{en}}{x_{al}}.$$

and the $x_{en}$ and $x_{al}$ have not changed, the condition that the I.V. be constant will be true only if

$$\frac{\mu_{al}^{40}}{\mu_{en}^{40}} = \frac{\mu_{al}^{30}}{\mu_{en}^{30}} = \text{constant} = K'.$$

If $\frac{\mu_{al}}{\mu_{en}} = K'$, then $\frac{(\mu/\rho)_{al}}{(\mu/\rho)_{en}} = \text{constant} = K''$,

since the densities ($\rho$) of Al and of enamel are also constants.

Thus if the ratios of the mass absorption coefficients are constant from 30 to 40 kv., the I.V. for enamel will be constant. The calculated mass absorption coefficients of Al and enamel at various λs (hence at various effective K.Vs.) together with the ratios of enamel to Al and dentine to Al are given in Table LVIII.

An increase in the kilovolt (peak) produces a decrease in the shortest λ (see Table LIX) as well as a decrease in the λ producing most of the roentgenographic intensity. From Table LIX, the shortest λ at 30 kv. is Å 0.42 Å, at 40 kv. is 0.32 Å. From Table LVIII, it is seen that at a uniform λ of 0.4 Å, the ratio of the mass absorption coefficient of Al to that of enamel is 1.62 and that at a uniform λ of 0.3 Å, the ratio is

TABLE LVIII

MASS COEFFICIENTS OF ABSORPTION FOR ALUMINUM, ENAMEL AND DENTINE AT VARIOUS WAVE LENGTHS AND THE RATIOS OF THE ABSORPTION COEFFICIENTS OF THE TOOTH TISSUES TO ALUMINUM

| $\lambda$ (Å) | $(\mu/\rho)_{al}$ | $(\mu/\rho)_{en}$ | $(\mu/\rho)_{dent.}$ | $\frac{(\mu/\rho)_{al}}{(\mu/\rho)_{en}}$ | $\frac{(\mu/\rho)_{al}}{(\mu/\rho)_{dent.}}$ |
|---|---|---|---|---|---|
| 0.5 | 1.95 | 3.25 | 2.15 | 1.70 | 1.01 |
| 0.4 | 1.04 | 1.75 | 1.20 | 1.62 | 1.01 |
| 0.3 | 0.50 | 0.82 | 0.60 | 1.51 | 1.01 |
| 0.2 | 0.25 | 0.37 | 0.25 | 1.33 | 1.01 |

1.51. It may also be seen (Bale's curves, Fig. 48) that the intensity peak, i.e., the $\lambda$ carrying the most intensity, shifts toward the shorter wave length as the kilovoltage

TABLE LIX

INCREASE OF PEAK KILOVOLTAGE WITH DECREASE IN SHORTEST WAVE LENGTH

| kv. (peak) | $\lambda$ shortest (Å) |
|---|---|
| 25 | 0.49 |
| 30 | 0.42 |
| 40 | 0.32 |
| 50 | 0.25 |
| 60 | 0.20 |

increases from 30 to 40 kv. Therefore, increasing the peak kilovoltage predictably should cause a decrease in the ratio of the mass absorption coefficient of Al to that of enamel.

But a decrease in the ratio of the mass absorption coefficients means that $\frac{\mu_{al}{}^{40}}{\mu_{en}{}^{40}}$ cannot equal $\frac{\mu_{al}{}^{30}}{\mu_{en}{}^{30}}$. It is evident that the I.V. for enamel cannot be constant. Furthermore, if the ratio of the mass absorption coefficient of Al to that of enamel decreases with increasing kv., then

$$\frac{\mu_{al}{}^{40}}{\mu_{en}{}^{40}} < \frac{\mu_{al}{}^{30}}{\mu_{en}{}^{30}}$$

and

$$\frac{x_{en}{}^{40}}{x_{al}{}^{40}} < \frac{x_{en}{}^{30}}{x_{al}{}^{30}}, \text{ but } x_{en}{}^{40} = x_{en}{}^{30},$$

therefore

$$\text{I.V.}_{\cdot en}{}^{40} > \text{I.V.}_{\cdot en}{}^{30}.$$

Thus, the thickness of Al at 40 kv. giving the same D.R. as the enamel is greater than the thickness of Al at 30 kv. giving the same D.R. as the enamel. But a greater thickness of Al giving the same D.R. means that the I.V. is greater, the observed increase in the I.V. for enamel is predicted theoretically. A similar argument may be used to extend this conclusion to account for the gradual increase in I.V's. for enamel at higher kilovoltages.*

Since the ratio of the mass absorption coefficient of aluminum to that of enamel is not constant with change of voltage, aluminum is not satisfactory as the standard for the comparative study of enamel. A suitable alloy standard having the same mass absorption coefficient as enamel has been described (see paper IV).

The average I.Vs. for dentine are 0.79 mm. Al at 20 kv., 0.8 mm. Al at 25 kv., 0.79 mm. Al at 32 kv., 0.81 mm. Al at 41 kv., 0.82 mm. Al at 51 kv. and 0.77 mm. Al at 61 kv. There is evidence of only a negligible change of I.Vs. for dentine with change in kilovoltage. From the preceding argument, this result is possible only on the condition that the ratio of the mass absorption coefficient of Al to that of dentine is constant. From Table LVIII, it is seen that this ratio is constant. The observed constancy of I.Vs. for dentine is thus predictable theoretically. Since the

* The effect of scattering by Al and by enamel on the magnitude of the I.V. for enamel is discussed earlier (see paper IV).

TABLE LX

FILM 21310 30 KV., 1 MACHINE PART A

| Step | Density | $d_f - d_{step}$ | $\mu$ | $\mu/\rho$ |
|---|---|---|---|---|
| 1 | 2.07 | .65 | 22.5 | 8.3 |
| 2 | 1.73 | .99 | 17.4 | 6.5 |
| 3 | 1.51 | 1.21 | 14.4 | 5.3 |
| 4 | 1.32 | 1.40 | 12.7 | 4.7 |
| 5 | 1.15 | 1.57 | 11.2 | 4.1 |
| 6 | 1.03 | 1.69 | 10.3 | 3.8 |
| 7 | 0.90 | 1.82 | 9.2 | 3.4 |
| 8 | 0.81 | 1.91 | 8.5 | 3.1 |
| Film | 2.72 | | | |

FILM 2134A 30 KV., 2 MACHINES PART B

| Step | Density | $d_f - d_{step}$ | $\mu$ | $\mu/\rho$ |
|---|---|---|---|---|
| 1 | 1.82 | .59 | 20.7 | 7.6 |
| 2 | 1.46 | .95 | 16.6 | 6.2 |
| 3 | 1.22 | 1.19 | 14.3 | 5.3 |
| 4 | 1.05 | 1.36 | 12.3 | 4.5 |
| 5 | 0.91 | 1.50 | 11.0 | 4.1 |
| 6 | 0.75 | 1.66 | 10.0 | 3.7 |
| 7 | 0.63 | 1.78 | 9.2 | 3.4 |
| 8 | 0.56 | 1.85 | 8.3 | 3.1 |
| Film | 2.41 | | | |

4 FILMS AT 30 KV. PART C

| Film Step | S34E51 d | $\mu$ | S34E50 d | $\mu$ | S34E49 d | $\mu$ | S34E47 d | $\mu$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.83 | 30.8 | 1.77 | 29.7 | 1.77 | 31.1 | 1.69 | 33.6 |
| 2 | 1.40 | 22.9 | 1.33 | 22.5 | 1.32 | 23.4 | 1.29 | 23.8 |
| 3 | 1.15 | 18.7 | 1.09 | 18.3 | 1.05 | 19.3 | 1.05 | 19.1 |
| 4 | 0.96 | 15.9 | 0.90 | 15.6 | 0.88 | 16.2 | 0.87 | 16.2 |
| 5 | 0.79 | 14.1 | 0.75 | 13.7 | 0.74 | 14.1 | 0.74 | 14.0 |
| 6 | 0.67 | 12.5 | 0.63 | 12.2 | 0.62 | 12.5 | 0.63 | 12.4 |
| 7 | 0.57 | 11.1 | 0.53 | 10.8 | 0.56 | 10.9 | 0.54 | 10.9 |
| 8 | 0.54 | 9.8 | 0.51 | 9.5 | 0.54 | 9.6 | 0.50 | 9.7 |
| Film | 2.71 | | 2.62 | | 2.66 | | | |

ratio of the mass absorption coefficient of Al to be that of dentine is constant (i.e., both from theory and from test data), no matter what the voltage, aluminum is a satisfactory standard for obtaining interpolated values for dentine.

The equation (1) may also be used to calculate $\mu_{effective}$ for the various steps of the penetrometer. A few typical examples of these calculations will be shown and data obtained on the same penetrometers with the same tube-machine combination but measuring the intensities by an ionization chamber will be offered for comparison. In general, the $\mu_{effective}$ measured densitometrically agrees in magnitude with the $\mu_{effective}$ measured by the ionization chamber method.

Using the equation

$$\frac{1}{\Gamma}(d_{film} - d_{step}) = \mu_{effective} x_{step}$$

since $\Gamma$ is known, $d_{film}$ and $d_{step}$ are read and $x_{step}$ is known, by substituting the

D.Rs., a value for $\mu_{effective}$ may be obtained.

In Table LX, part A, are given the DRs., the differences, ($d_{film}-d_{step}$) the $\mu_{effective}$ and the $\mu/\rho$ from Film 21310 taken at 30 kv. In Figure 43, the differences ($d_0-d_{1,2,3}$, etc.) are plotted against the proper thicknesses of Al and give the upper smooth curve. The $\mu_{effective}$ vary from 22.5 under Step 1 to 8.5 under Step 8; they form a smooth curve when plotted (Fig. 44) against the proper thicknesses of Al.

In Table LX, part B, are given similar data from Film 2134 A taken at 30 kv. with two machines (see change of milliamperage, paper III). The curve obtained when $\mu_{effective}$ is plotted against the step thickness is almost coincident with that with one machine (Fig. 44).

In Table LX, part C, are given similar data from 4 films taken at 30 kv. after the equipment had been overhauled and adjusted. The $\mu_{effective}$ are of slightly greater but comparable magnitudes.

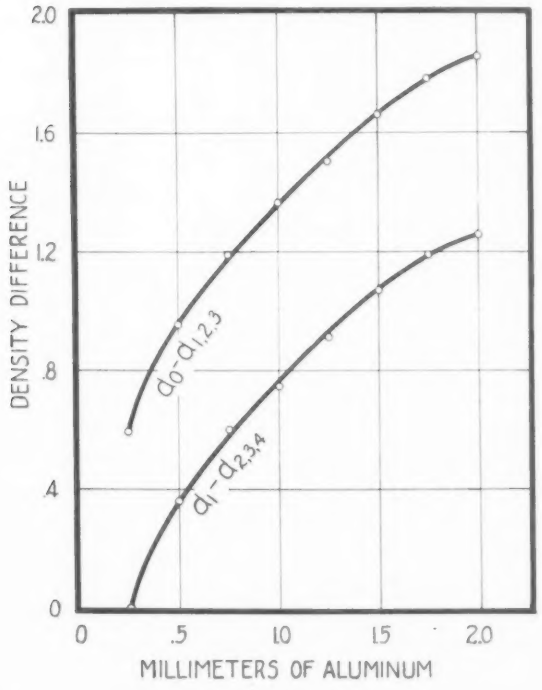


FIG. 43. The differences ($d_{film}-d_{step}$) and ($d_{step\ 1}-d_{step\ 2,3,4,etc.}$) in density units are plotted as ordinates against the proper thicknesses of Al. The two smooth curves are more or less parallel but the ($d_{step}-d_{step\ 2,3,4,etc.}$) curve placed sufficiently lower to give lower values for the absorption coefficients (compare Fig. 44).

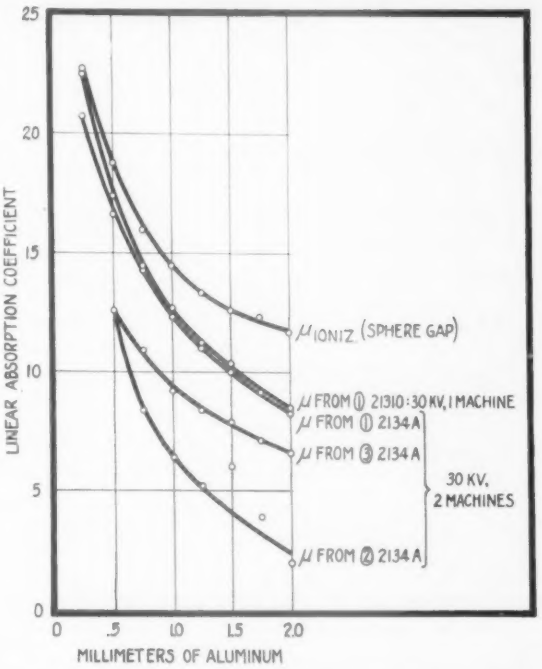


FIG. 44. Absorption coefficients (linear) are plotted as ordinates against the proper thicknesses of Al. The $\mu$ curve from ionization data is placed above and has a smaller radius of curvature than the $\mu$ curves from densitometric data. Using equation (1), a good correspondence is shown whether 1 or 2 machines are employed. The curves using equation (1) are almost coincident with the curve from ionization data in the thinner steps but there is an increasing divergence for the thicker steps. The curve from equation (3) is lower (compare Fig. 43). The curve from equation (2) is not only markedly lower but the values for the thicker steps are scattered.

In Table LXI are given calculations of $\mu_{effective}$ using equation (3) which in form is as follows:

$$\frac{I}{\Gamma}(d_1-d_{2,3,4,etc.}) = \mu_{effective}(x_{2,3,4,etc.}-x_1)_{step}. \qquad (3)$$

In Table LXI, part A, are given the data from Film 21310. It may be seen that the $\mu_{effective}$ are much lower in magnitude than those obtained from equation (1). From the lower curve in Figure 43, it is evident that the reason for the lower $\mu_{effective}$ is in the lower value of the differences ($d_1$

$-d_{2,3,4}$. etc.). The difference curve for equation (3) is much like that from equation (1) but placed lower.

TABLE LXI

PART A

Film 21310 30 kv. Machine

| Step | $(d_1-d_{2,3,\text{ etc.}})$ | $\mu_{2,3,\text{ etc.}}$ | $\frac{\mu}{\rho}$ |
|---|---|---|---|
| 1 | | | |
| 2 | 0.34 | 11.9 | 4.5 |
| 3 | 0.56 | 10.2 | 3.8 |
| 4 | 0.75 | 9.2 | 3.4 |
| 5 | 0.92 | 8.4 | 3.2 |
| 6 | 1.04 | 7.8 | 2.9 |
| 7 | 1.17 | 7.1 | 2.7 |
| 8 | 1.26 | 6.6 | 2.5 |

PART B

Film 2139A

| Step | $d_1-d_{2,3,4,\text{ etc.}}$ | $\mu_{2,3,4,\text{ etc.}}$ | $\frac{\mu}{\rho}$ | $\frac{\mu_{\text{ionis.}}}{\mu}$ |
|---|---|---|---|---|
| 1 | | | | |
| 2 | 0.36 | 12.6 | 4.7 | 1.49 |
| 3 | 0.60 | 10.9 | 4.1 | 1.47 |
| 4 | 0.75 | 9.2 | 3.4 | 1.58 |
| 5 | 0.91 | 8.4 | 3.2 | 1.58 |
| 6 | 1.07 | 7.9 | 2.9 | 1.59 |
| 7 | 1.19 | 7.1 | 2.7 | 1.73 |
| 8 | 1.26 | 6.6 | 2.5 | 1.77 |

In Table LXI, part B, are given similar data from Film 2134 A. The $\mu_{\text{effective}}$ are similar in magnitude to those in Table V d2, part A, and when plotted against the proper thicknesses of Al, a smooth curve is formed (Fig. 44) which is transposed markedly lower as compared to the curves from equation (1).

(In Table LXII, are given data from Film 2134 A, calculated from equation (2) above which is of the following form:

$$\frac{I}{\Gamma}(d_{1,2,3,\text{etc.}}-d_{2,3,4,\text{etc.}})$$

$$=\mu_{\text{effective}}\times\text{average for 2 steps.}$$

The $\mu_{\text{effective}}$ fall very rapidly when plotted against the proper thickness of Al (Fig. 44) and give badly scattered values for the thicker steps (probably because it is in the flattened end of the D.T. curve where the density differences are so small).

To check the $\mu_{\text{effective}}$ as calculated from D.Rs., Bale measured the $\mu_{\text{effective}}$ using the ionization chamber method. His data at 30 kv. are given in Table LXIII, part A, the kv read from the Instrument Board, and part B, the kv determined by sphere gap measurements. The data are given in terms of the seconds needed for the galvanometer

TABLE LXII

FILM 2134A

| Step | $(d_{1,2}-d_{2,3})$ | $\mu_{2,3,\text{ etc.}}$ | $\frac{\mu}{\rho}$ |
|---|---|---|---|
| 1 | | | |
| 2 | 0.36 | 12.6 | 4.7 |
| 3 | 0.24 | 8.4 | 3.1 |
| 4 | 0.17 | 6.4 | 2.5 |
| 5 | 0.14 | 5.2 | 1.9 |
| 6 | 0.16 | 6.0 | 2.2 |
| 7 | 0.12 | 3.9 | 1.5 |
| 8 | 0.07 | 2.0 | 0.7 |

(connected with the ionization chamber) to reach a deflection of 40, calculations then being based on the assumption that the number of seconds is inversely proportional to the intensities of the beams, i.e.,

$$\ln\frac{I_0}{I_1}=\mu_1 x_1=\ln\frac{t_1}{t_0}$$

where $t_0$ and $t_1$ represent the time (seconds) necessary for the galvanometer to swing to 40. The percentages of the primary beam transmitted at 30 and 40 kv. are shown graphically as ordinates against the appropriate thicknesses of filter (step of penetrometer) in Figure 45. Evidently carefully controlling the kilovoltage has a pronounced effect on the data obtained, so that most of the kilovoltages interpolated from the instrument board of the roentgenographic machine are really 3 to 10 kv. lower than read. The $\mu$ from Table LXIII are plotted in Figure 46, a regular difference between the $\mu$-x (analogous to density-

TABLE LXIII

PART A

30 kv. Instrument Board

| Step | Seconds to reach 40 | $\mu$ | $\frac{\mu}{\rho}$ |
|---|---|---|---|
| 0 | 2.3 | 00.0 | 00.0 |
| 1 | 5.0 | 28.9 | 10.7 |
| 2 | 7.5 | 22.4 | 8.3 |
| 3 | 10.0 | 19.2 | 7.1 |
| 4 | 13.5 | 17.7 | 6.5 |
| 5 | 18.0 | 16.6 | 6.1 |
| 6 | 22.0 | 15.3 | 5.7 |
| 7 | 28.0 | 14.2 | 5.3 |
| 8 | 34.0 | 13.4 | 5.0 |

PART B

30 kv. Sphere Gap

| Step | $\frac{I_0}{I}$ | $\ln \frac{I_0}{I}$ | $x_{cm.}$ | $\mu$ | $\frac{\mu}{\rho}$ |
|---|---|---|---|---|---|
| 1 | 1.77 | 0.57098 | 0.025 | 22.8 | 8.4 |
| 2 | 2.56 | 0.94001 | 0.050 | 18.8 | 7.0 |
| 3 | 3.33 | 1.20297 | 0.075 | 16.0 | 6.0 |
| 4 | 4.26 | 1.44927 | 0.100 | 14.5 | 5.4 |
| 5 | 5.26 | 1.66013 | 0.125 | 13.3 | 5.0 |
| 6 | 6.67 | 1.89763 | 0.150 | 12.6 | 4.7 |
| 7 | 8.55 | 2.14593 | 0.175 | 12.3 | 4.5 |
| 8 | 10.42 | 2.34373 | 0.200 | 11.7 | 4.3 |

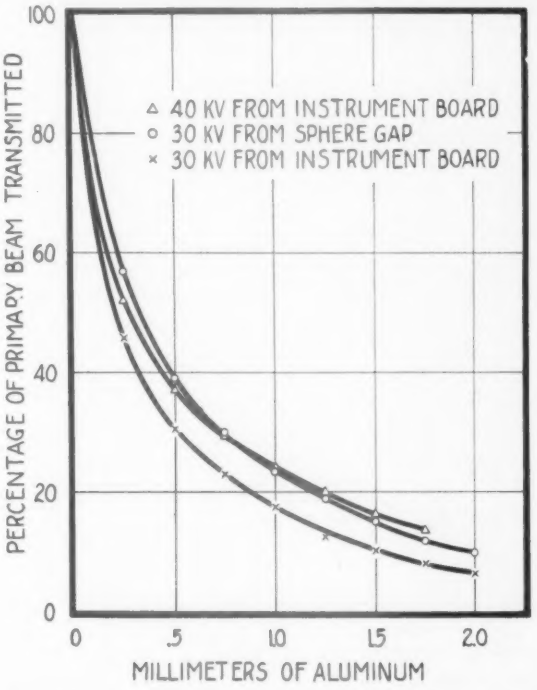


FIG. 45. The percentage transmission through the various steps are plotted as ordinates against the respective thicknesses. The curves for 40 kv. (read on the instrument board) and for 30 kv. (registered by a sphere gap) are crossed and closely laid. The curve for 30 kv. (instrument board) is similar in shape but placed below the other two curves.

thickness curves) are observed, the $\mu$ from the kv. read from the instrument board being greater for each step indicating that decreasing kilovoltage increases the apparent effective $\mu$ value for every step in proportion. The magnitude of $\mu_{1\ (\text{sphere gap})}$ is about 23, of $\mu_8$ is about 12. The magnitude of $\mu_{1\ (\text{instrument board})}$ is about 29, of $\mu_8$ about 13. Comparing these values with those obtained densitometrically it is evident that the $\mu_{\text{effective}}$ are of comparable magnitudes whether measured by ionization or densitometric methods.

It is also evident that the discrepancy between the $\mu$ obtained by ionization and the $\mu$ from equation (1) increases with increased thickness of step. A partial explanation of this increase may be found in the higher fog values under the thicker (lighter) steps, increasing the density relative to the darker steps (see discussion later).

For monochromatic roentgen radiation, a given thickness of filter will absorb a given propertion of the incident ray, from which proportion is calculated its absorption coefficient. If another such beam, whose wave length is shorter, is substituted, the filter will absorb a smaller proportion of the incident ray and the absorption coefficient will be a smaller number. The equation of Duane and Mazundar expressing this fact shows the $\mu$ decreases as the cube of the wave length. Since the equation (1) permits the calculation of $\mu_{\text{effective}}$ and since the relations of $\mu$ and $\lambda$ are already established for monochromatic beams, we may make an interesting interpolation to obtain values of wave length described in analogous convention as the $\lambda_{\text{effective}}$. Thus, if a certain beam gives

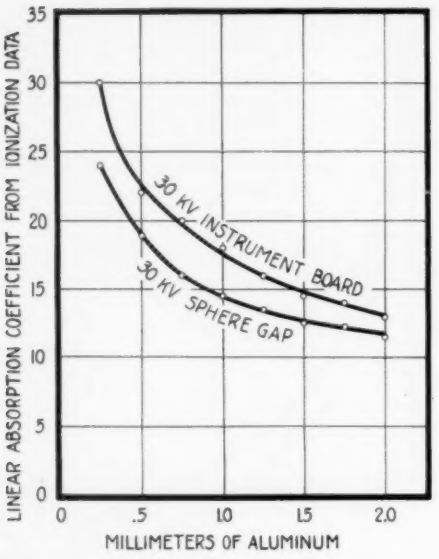


FIG. 46. The absorption coefficients (linear) are plotted against the various thicknesses of Al as abscissae. The curve for 30 kv. (instrument board) is above but similar to the curve for 30 kv. (sphere gap) (compare Fig. 45).

a $\mu_{effective}$, and that value is interpolated from a $\mu$-$\lambda$ curve, the $\lambda_{effective}$ found would be the $\lambda$ of a monochromatic beam which would produce that $\mu$.

We have presented (Fig. 18) the curves showing the relation between mass absorption coefficients and wave length for Al. By interpolating the $\mu/\rho$ from Tables LX and LXIII we obtain a series of $\lambda_{effective}$ values at 30 kv. which vary from about 0.9 Å under Step 1 to 0.6 Å under Step 8. As may be seen from Table LXIV, the values of $\lambda_{effective}$ obtained densitometrically are of comparable magnitude to the values of $\lambda_{effective}$ from ionization measurements.

In Figure 47 are given calculated wave lengths of the hardest component of the beams at various peak kilovoltages. It is evident that for $\lambda$s longer than 0.3 Å, there is a rapid increase in $\lambda$ with decrease in kv. Since we are working at kilovoltages less than those for which the shortest $\lambda$ is 0.3 Å, we may expect to find fairly wide variations in $\lambda_{effective}$ particularly under the thicker steps. However, this is not the whole story. Most of the intensity of a given white beam is carried not by the shortest $\lambda$ but by some longer $\lambda$. In Figure 48 are given intensity curves at 30, 40 and 50 kv. (unpublished data of Bale) from ionization measurements made on the tube-machine combination with which the measurements of Tables LX et seq. were made. It is interesting to note in confirmation of the $\lambda_{effective}$ values in Table LXIV that the greatest intensity of the white beam at 30 kv. is at a wave length of near 0.6 Å.

The characterization of the roentgen-ray beam densitometrically has been approached in the past by a quite different technique. The usual stipulation of roentgen-ray quality is by means of the half-value layer. It is easy to see that if

$$\ln \frac{I_0}{I_{1/2}} = \frac{1}{\Gamma}(d_{film} - d_{1/2}) = \mu x_{1/2}$$

where $I_{1/2}$ is the intensity of half the original intensity, then $d_{1/2}$ is the density under the half-value layer and $X_{1/2}$, the half-

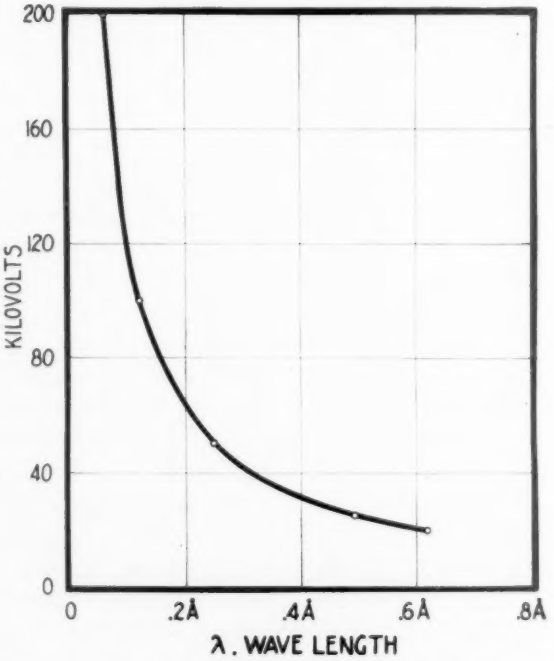


FIG. 47. The peak kilovoltage is plotted (ordinate) against the shortest wave length roentgen ray produced at the stated kilovoltage (compare Fig. 48). We are indebted to Mr. W. F. Bale for the calculations of wave length at the various kilovoltages.

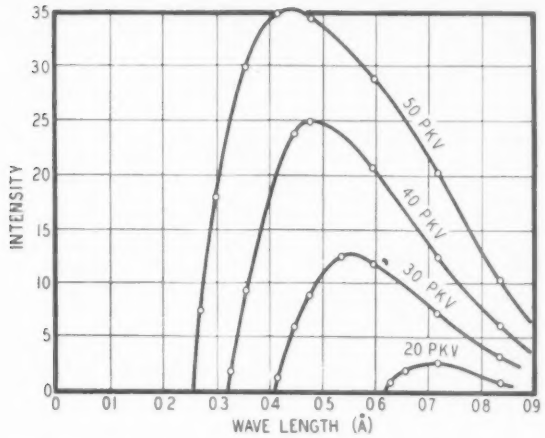


Fig. 48. The intensity (from ionization measurements made by W. F. Bale) is plotted (ordinate) as a function of the wave length. Compare Ulrey's curves, p. 47, Fig. 24, "Science of Radiology," edited by Glasser, Charles C Thomas, Springfield, Ill., 1933, or see Ulrey, *Phys. Rev.*, 1918, *11*, 40.

value layer. Since

$$I_0 = 2I_{1/2}$$

then $$\ln 2 = \frac{I}{\Gamma}(d_{film} - d_{1/2})$$

or $$0.7 = \frac{I}{1.1}(d_{film} - d_{12})$$

$$0.8 = d_{film} - d_{1/2}.$$

Thus the magnitude of the difference $(d_\Gamma - d_{1/2})$ should be about 0.8.

The half-value layer of Al at 30 kv. according to Duane is 0.035 cm., from our ionization data we get 0.023 cm. Al interpolating from the "instrument board" curve (Fig. 45) and 0.035 cm. Al interpolating from the "sphere gap" curve (Fig. 45). Thus with densitometric values probably more closely comparable to the instrument board values than to the sphere gap values it is interesting to note in confirmation from Table LV that under 0.025 cm. Al, most of the differences (d film − d step 1) are grouped around 0.76. Thus, for a given kv., the half-value layer is easily calculated densitometrically.

Using equation (1) we may also calculate an "effective" Γ since:

$$\frac{I}{\Gamma}(d_{film} - d_{step}) = \mu_{step} x_{step}.$$

The results of the calculations are tabulated in Table LXV. The calc. Γ run from 1.1 under Step 1 to 0.8 under Step 8. The calc. Γ are plotted as ordinates vs. the thickness of the steps in Figure 49 (compare Γ found in the usual way in a later paper) where a linear relation is found between Γ and thickness of Al. In the same figure, the $\Gamma_{calc.}$ are plotted against the effective λ where again a linear relation is found excepting a marked deviation under Steps 7 and 8. The decrease in the magnitude of the $\Gamma_{calc.}$ with increase in thickness of filter may be in part due to the fact that lower densities under the thicker steps are placed lower (toward the toe) on the characteristic density curve and therefore represent a real decrease in contrast. On the other hand, the decrease may be due to a dependency of gamma on the wave length (Fig. 50).

For a given film, gamma varies with the development time (see Fig. 41 and Fig. 50). If the development time is kept constant,

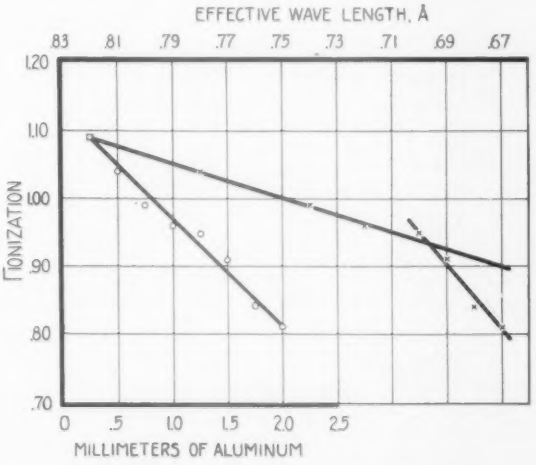


Fig. 49. The gammas (calculated from ionization data) are plotted (ordinates) against the various thicknesses of steps (lower line and lower abscissae) and also against the effective wave length (Å) (upper two lines and upper abscissae). More or less linear relations appear for both functions excepting the apparent break for the wave length values under the two thickest steps (right end of upper line).

TABLE LXIV

EFFECTIVE WAVE LENGTH IN Å

| | Densitometric Values | | | | | | Ionization Values | |
|---|---|---|---|---|---|---|---|---|
| Film No. | 21310 | 21314A | S34E51 | S34E50 | S34E49 | S34E47 | Instrument Board | Sphere Gap |
| *Step* | | | | | | | | |
| 1 | 0.82 | 0.80 | 0.90 | 0.89 | 0.91 | 0.92 | 0.88 | 0.82 |
| 2 | 0.77 | 0.75 | 0.83 | 0.82 | 0.83 | 0.83 | 0.83 | 0.78 |
| 3 | 0.72 | 0.72 | 0.78 | 0.77 | 0.78 | 0.78 | 0.79 | 0.74 |
| 4 | 0.69 | 0.67 | 0.74 | 0.73 | 0.74 | 0.74 | 0.77 | 0.72 |
| 5 | 0.66 | 0.66 | 0.71 | 0.71 | 0.71 | 0.71 | 0.75 | 0.70 |
| 6 | 0.64 | 0.63 | 0.68 | 0.68 | 0.68 | 0.68 | 0.73 | 0.69 |
| 7 | 0.62 | 0.62 | 0.65 | 0.65 | 0.65 | 0.65 | 0.71 | 0.68 |
| 8 | 0.60 | 0.60 | 0.63 | 0.63 | 0.63 | 0.63 | 0.69 | 0.67 |

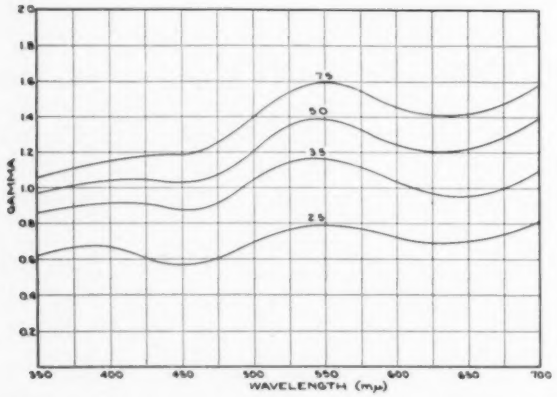


FIG. 50. Spectral sensitivity curves. (Courtesy of L. A. Jones, Physics Department of Eastman Kodak Company.) Gamma (ordinate) is shown to vary with the wave length in a definite but periodic way. Gamma increases for any given wave length with development time (compare Fig. 41).

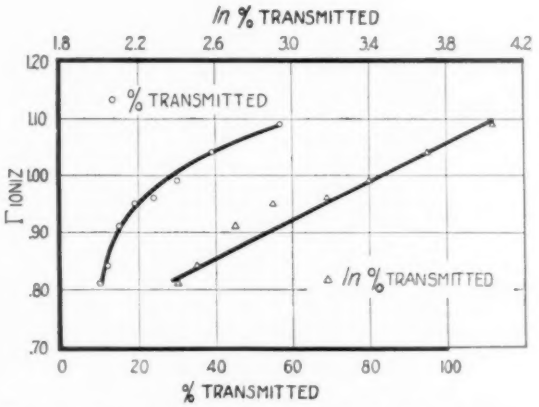


FIG. 51. Gamma calculated from ionization measurements is plotted (ordinate) against percentage of the beam transmitted (upper curve and lower abscissae) and also against the logarithm (to the base *e*) of the percentage transmitted (straight line and upper abscissae).

TABLE LXV

GAMMA FROM IONIZATION DATA

| Γ calc. Sphere Gap | Γ calc. Instrument Board |
|---|---|
| 0.91 | 1.09 |
| 0.96 | 1.04 |
| 1.01 | 0.99 |
| 1.04 | 0.96 |
| 1.05 | 0.95 |
| 1.10 | 0.91 |
| 1.19 | 0.84 |
| 1.23 | 0.81 |

gamma varies with the λ of the incident radiation (Jones, page 124) (Fig. 51). In this graph 1 inch = 100 millimicrons. In the roentgen-ray spectrum, the extreme limits of λ are from about 0.01 to 15 millimicrons which would be proportionately about 0.15 of an inch on the same scale. Furthermore the λ we are interested in vary only from about 0.05 to 0.08 millimicrons which would occupy a λ increment on the same base line of 0.003 of an inch. Consequently it might be argued that only negligible differences in gamma may be expected in the λ range of our experiments. However, with equal justice it may be pointed out that the photon of the roentgen ray beam (as of the light beam) has an energy con-

tent in inverse ratio to its λ, so that the effect of small changes in λ may be greatly magnified. Thus, the variation in Γ found may represent real changes as a function of the wave length. It may be attributable in some part to the larger effect of fog in the lower densities. It may be an artifact, but, if real, its significance if any is not clear at present.

TABLE LXVI

INTENSITY MEASURED BY IONIZATION AS A FUNCTION OF THICKNESS OF ALUMINUM

| Thickness (mm.) | Intensity % transmitted |
|---|---|
| 2.00 | 9.6 |
| 1.75 | 11.7 |
| 1.50 | 15.0 |
| 1.25 | 19.0 |
| 1.00 | 23.5 |
| 0.75 | 30.0 |
| 0.50 | 39.0 |
| 0.25 | 56.6 |
| 0.00 | 100.0 |

Since we know the percentage transmitted by each step using white radiation (Table LXVI), we may study the relation between the percentage transmission and $\Gamma_{calc.}$ from ionization measurements, (Γ ionization).

$$\ln \% \text{ transmitted} = \ln \left[ \frac{I_{step}}{I_0} \times 100 \right]$$

$$= \frac{100}{\Gamma} (d_{film} - d_{step}).$$

Plotting the $\Gamma_{ionization}$ as ordinates vs. the percentage transmitted, a smooth curve is obtained (Fig. 51) which decreases in slope with increasing percentage transmitted, i.e., with thinner steps. However, when the $\Gamma_{ionization}$ is plotted vs. the ln of the per cent transmitted, a linear relation is discovered as would be predicted from the equation above.

SUMMARY

1. By combining the equation for roentgen-ray absorption in filters with the equations for photographic exposure and photographic density a specialized equation is obtained as follows:

$$\ln \frac{I_{film}}{I_{tissue}} = \frac{1}{\Gamma} (d_{film} - d_{tissue})$$

$$= \mu_{tissue} x_{tissue} \qquad (1)$$

which is shown to hold for certain stringently controlled conditions.

2. By the use of equation (1), the effective mass coefficients of absorption of dentine and of enamel may be calculated and are shown to compare well with values calculated from chemical data (paper IV).

3. The increase of I.V. for enamel with increasing kilovoltage and the constancy of I.V. for dentine may be predicted using equation (1).

4. Using equation (1) the effective mass absorption coefficients ($\mu_{effective}$) for the various steps of the aluminum penetrometer may be calculated and are shown to be of comparable magnitudes to the $\mu_{effective}$ obtained by ionization measurements.

5. The $\mu_{effective}$ values may be used to obtain interpolated effective wave length values ($\lambda_{effective}$), thus describing the quality of the transmitted radiation. The half-value layer may be calculated from equation (1).

6. "effective" gamma (Γ) for the emulsion is calculated for the different effective wave lengths transmitted by the various steps of the penetrometer.

We wish to acknowledge our indebtedness to Grant Van Huysen for densitometer readings, to W. F. Bale for ionization data, to R. B. Wilsey for development time data and for the characteristic curves (Fig. 42), to L. A. Jones for the spectral sensitivity curves (Fig. 50).

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*Thirty-seventh Annual Meeting:* Cleveland Hotel, Cleveland, Ohio, Sept. 29-Oct. 2, 1936.

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*Twenty-second Annual Meeting:* Atlantic City, N. J., June 7-8, 1937.

# EDITORIAL

## PROTRUSION OF THE INTERVERTEBRAL DISC INTO THE SPINAL CANAL

SINCE Schmorl's classical studies on the spinal column there has arisen a new interest both in the normal anatomy and in the pathologic states of the spinal column, and not the least of these has had to do with diseases and injuries to the intervertebral discs. Not until Dandy's publication[1] in 1929 on loose cartilages from intervertebral discs simulating tumor of the spinal cord was it appreciated that a slight or apparently trivial trauma, in which there occurred posterior dislocation of a portion of the nucleus pulposus into the spinal canal, could produce such disabling symptoms. Dandy reported two cases in which fragments of loose cartilages from the intervertebral disc had become displaced into the spinal canal and gave rise to signs and symptoms which were progressive and associated with pain in the spinal column so severe that presumptive diagnoses of carcinoma of the vertebrae were made. In these patients the pain radiated down the back of both legs but usually down one more than the other. The side most involved proved to be the side of the greater bulge of the tumor. These facts led Dandy to wonder whether bilateral sciatic pains do not in most instances indicate a lesion affecting the spinal cord or cauda equina, more frequently the latter. He also called attention to the significant fact that in these two cases the dislocation of the cartilage occurred in the lumbar region which he explained on the basis that the maximum effects of shocks or torsion of the body are transferred to the lumbar spine and it is anatomically true that the intervertebral discs attain their greatest size in the lumbar region. He also pointed out that the posterior dislocation of the nucleus was the most likely because the normal anterior curvature of the lumbar spine would be expected to throw greater localized effects of trauma on the posterior side of the disc and that the relatively thin and incomplete posterior ligaments of the lumbar spine should more readily permit protrusion of a tumor in the intervertebral disc than the stronger and complete anterior ligament.

Whatever the causative factor, the fact remains that the discs do herniate posteriorly and that it occurs much more frequently than we are apt to think, as indicated by the number of reports that have followed Dandy's original observations. Dandy called attention to and emphasized the fact that seemingly trivial injuries were the provocative factors in his two cases and he suggests that there must be many instances in which the intervertebral cartilage sustains the degree and character of injury experienced in his two cases and yet subsequently heals instead of going on to sequestration. He raises the rather pertinent question as to whether complete detachment of the cartilage fragment does not require considerable time and that with proper rest and fixation of the spine this outcome may be avoided.

The roentgen examination in his two cases disclosed nothing of diagnostic value but he emphasized the point that only anteroposterior views were taken before operation but that in one of his cases following operation a lateral view of the spine revealed not the slightest abnormality.

[1] Dandy, W. E. Loose cartilage from intervertebral disk simulating tumor of the spinal cord. *Arch. Surg.*, 1929, *19*, 660–672.

The diagnosis of the presence of a protruding disc is not always easy and, as Love[2] says, at times it may be most difficult, and in suspected cases a most careful search for the protrusion may be necessary in order to prevent its being overlooked. Herniation of the nucleus pulposus into the spinal canal may occur at any level of the movable part of the spinal column but the most common site of occurrence has been in the lumbar region and the most common associative symptom has been sciatic pain. Cases in which definite neurological findings have developed may present no particular problem in diagnosis, but there are borderline cases which are more difficult to diagnose, especially those in which pain is the only symptom and in which the neurological examination gives negative results. It is in these cases that the roentgen examination is of the greatest importance. Roentgenograms of the spinal column may disclose a narrowed intervertebral space, which may suggest the possibility of an extruded disc or, as in Dandy's cases, the roentgen examination may be entirely negative. Most often the diagnosis of the condition is dependent upon roentgenoscopic and roentgenographic examinations of the spinal canal after the injection of lipiodol into the subarachnoid space. Love calls attention to the importance of the selection of patients for this diagnostic procedure because it is obviously impossible to subject all patients who complain of obscure sciatic pain to this form of study. He has found that certain points have been of value in the selection of patients for study with lipiodol: "First, patients are selected who have pain that follows the distribution of one or more spinal nerve roots for a considerable period and who have not been benefited appreciably by the usual conservative and therapeutic measures employed for the relief of distress in that particular region. Second, patients whose cerebrospinal fluid, obtained on lumbar puncture, contains more than 40 mg. of total protein per 100 c.c. of fluid and reacts positively to a test for globulin should be subjected to injection of lipiodol, a value of less than 40 mg. for total protein does not exclude the possibility of an extruded disk with compression of a nerve root. . . .

"The third, and in our experience a most important criterion for the use of lipiodol intraspinally in cases of low back and sciatic pain, is the result of the reversed Queckenstedt test. This test at times gives the real and only clue to the cause of the trouble."

Camp, in his discussion of Love's paper, calls particular attention to the necessity of observing meticulous technique in the examination of those cases of suspected protrusion or herniation of the nucleus pulposus. He advocates an adequate amount of radiopaque oil in the subarachnoid space in order to visualize small nonobstructing tumors which may be identified by a filling defect, which assumes a characteristic shape depending on whether the lesion is extradural, subdural, or intramedullary. Five cubic centimeters of radiopaque oil is usually injected into the subarachnoid space and the excursion of the oil is studied on a tilting roentgenoscopic table while the patient is in the prone, supine, lateral and oblique positions. Since protruding discs are situated in the anterior portion of the spinal canal they of necessity would produce their maximum filling defect when the patient is lying prone. In this position the oil gravitates to the ventral portion of the spinal canal and is in direct contact with the protruding disc. If the patient is only examined in the supine position a filling defect may be missed since in this position the oil will gravitate to the posterior aspect of the canal away from the protruding disc. Complete obstruction to the free flow of the radiopaque oil may occur where large protrusions of the disc take place but the diagnosis is a little more difficult when only a small fragment of the disc protrudes into the spinal canal. It is therefore of extreme importance that the

[2] Love, J. G. Protrusion of the intervertebral disk (fibrocartilage) into the spinal canal. *Proc. Staff Meet. Mayo Clinic*, Aug. 19, 1936, *11*, 529–535.

patient be examined in the various positions but Camp emphasizes the importance of the prone position which is too frequently neglected in examinations of this sort. He also emphasizes the importance of a roentgenoscopic study of the passage of the radiopaque oil throughout the full extent of the spinal canal as there may be more than one protrusion into the canal and there may not infrequently be an associated spinal cord tumor at a higher level.

Recently Abbott[3] has called attention to the possibility of the compression of the cauda equina by the ligamentum flavum. Previous to his paper only three cases had been reported. The ligamenta flava stretch across the posterolateral aspect of the spinal canal between the laminae. The ligaments, composed of yellow elastic tissue are attached to the anterior aspect of the superior laminae and posterior surface of the anterior. The two ligaments of each interlaminar space fuse in the midline and extend laterally to form the posterior margin of the intervertebral foramina. The ligament, as normally observed during laminectomy, is 1 or 2 mm. thick, and yellow. That these ligaments may occasionally be ruptured and the ruptured portion hypertrophied and cause pressure on the cauda equina, just as may the herniation of the nuclei pulposi into the spinal canal, is not generally appreciated and in the presence of an unexplained sciatic pain with or without associated neurological disturbances, the possibility of the herniation of a nucleus pulposus into the spinal canal or the rupture of a ligamentum flavum should be considered. That these may be demonstrated by the proper study of the spinal canal is indicated by the reports of Abbott, Camp and others,[4,5] and roentgenologists should be aware of the possibility of the occurrence of these pathological states which may apparently arise from trivial or slight traumas and go unrecognized.

[3] Abbott, W. D. Compression of the cauda equina by the ligamentum flavum. *J. Am. M. Ass.*, June 20, 1936, *106*, 2129–2130.

[4] Mixter, W. J., and Barr, J. S. Rupture of intervertebral disk with involvement of the spinal canal. *New England J. Med.*, 1934, *211*, 210–215.

[5] Schachtschneider, H. Der hintere Bandscheibenprolaps in seinen klinischen Auswirkungen. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, August, 1936, *54*, 107–129.

# SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

*Items for this section solicited promptly after the events to which they refer.*

## MEETINGS OF ROENTGEN SOCIETIES*

### UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
*Secretary*, Dr. F. P. Pendergrass, University Hospital, Philadelphia, Pa. Annual Meeting: Cleveland, Ohio, Sept. 29–Oct. 2, 1936.

AMERICAN COLLEGE OF RADIOLOGY
*Secretary*, Dr. B. H. Orndoff, 2561 N. Clark Street, Chicago, Ill. Annual meeting, 1937: To be announced.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
*Secretary*, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting, 1937: To be announced.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
*Secretary*, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N.Y. Annual meeting: Cincinnati, Ohio, Nov. 30–Dec. 4, 1936.

RADIOLOGICAL SECTION, BALTIMORE CITY MEDICAL SOCIETY
*Secretary*, Dr. Howard H. Ashbury, Baltimore. Meets third Tuesday each month, September to May.

RADIOLOGICAL SECTION, CONNECTICUT STATE MEDICAL SOCIETY
*Secretary*, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets annually in May. Special meetings may be called by the Chairman.

RADIOLOGICAL SECTION, LOS ANGELES COUNTY MEDICAL SOCIETY
*Secretary*, E. N. Liljedahl, Los Angeles, Calif. Meets on the second Wednesday of each month at the County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
*Secretary*, Dr. Roy G. Giles, Temple, Texas. Annual meeting, Baltimore, Md., Nov. 17–20, 1936.

BROOKLYN ROENTGEN RAY SOCIETY
*Secretary*, Dr. E. Mendelson, 120 E. 19th St., Brooklyn, N. Y. Meets monthly on first Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
*Secretary-Treasurer*, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

CHICAGO ROENTGEN SOCIETY
*Secretary*, Dr. R. G. Willy, 1138 N. Leavitt. Meets second Thursday of each month October to May inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
*Secretary*, Dr. H. G. Reineke, General Hospital Cincinnati, Ohio. Meets third Monday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
*Secretary*, Dr. North W. Shetter, 14600 Detroit Ave. Meetings are held at 6:30 P.M. at the Cleveland Chamber of Commerce Club rooms on the fourth Monday of each month from October to April, inclusive.

DENVER RADIOLOGICAL CLUB
*Secretary*, Dr. K. D. A. Allen, 452 Metropolitan Building, Denver, Colorado. Meets on any month having a fifth Monday.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
*Secretary*, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne Country Medical Society Building.

FLORIDA STATE RADIOLOGICAL SOCIETY
*Secretary*, Dr. Harold O. Brown, Tampa, Florida. Meetings held twice a year, May and November.

ILLINOIS RADIOLOGICAL SOCIETY
*Secretary*, Dr. Cesare Gianturco, 602 W. University Ave., Urbana, Ill. Regular meetings held quarterly.

INDIANA ROENTGEN SOCIETY
*Secretary*, Dr. C. C. Taylor, Indianapolis, Ind. Meeting held the second Sunday in May annually.

LONG ISLAND RADIOLOGICAL SOCIETY
*Secretary*, Dr. S. G. Schenck, 115 Eastern Parkway, Brooklyn, N. Y. Meets on third Thursday of each month from October to May, at 8:30 P.M.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
*Secretary*, Dr. C. S. Davenport, St. Lawrence Hospital, Lansing, Mich. Three meetings a year, Fall, Winter, and Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
*Secretary*, Dr. S. A. Morton, Columbia Hospital, Milwaukee, Wis. Meets monthly. Place of meeting designed by the president.

MINNESOTA RADIOLOGICAL SOCIETY
*Secretary*, Dr. L. G. Rigler, University Hospital, Minneapolis, Minn.

NEBRASKA STATE RADIOLOGICAL SOCIETY
*Secretary*, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday evening of each month.

NEW ENGLAND ROENTGEN RAY SOCIETY
*Secretary*, Dr. E. C. Vogt, 300 Longwood Ave., Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
*Secretary*, Dr. P. S. Avery, New Brunswick, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by the president.

NEW YORK ROENTGEN SOCIETY
*Secretary*, Dr. E. F. Merrill, 30 W. 59th St., New York. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
*Secretary*, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
*Secretary*, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse, N. Y. Three meetings a year—January, May, and November.

PACIFIC ROENTGEN CLUB
*Secretary*, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
*Secretary*, Dr. L. E. Wurster, Williamsport, Pa. Two day annual meeting held in May or June. Time and place of next meeting to be announced later.

PHILADELPHIA ROENTGEN RAY SOCIETY
*Secretary*, Dr. Thomas Loughery, Germantown Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
*Secretary*, Dr. Camp C. Thomas, 476 Lake Ave. Meets on second Thursday from October to May, inclusive, 8 P.M., Rochester Academy of Medicine Building.

ST. LOUIS ROENTGEN RAY SOCIETY
*Secretary*, Dr. P. C. Schnoebelen, Missouri Bldg., St. Louis, Mo. Meets first week of each month. Time and place of meetings designated by president.

SOUTH CAROLINA X-RAY SOCIETY
*Secretary*, Dr. R. B. Taft, 105 Rutledge Ave., Charleston. Meets at time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY
*Secretary*, Dr. F. B. Bogart, 311 Medical Arts Bldg.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
*Secretary-Treasurer*, Dr. J. H. Smith, Lubbock, Texas
Meets annually one day preceding the meeting of the Texas State Medical Association.

University of Michigan Department of Roentgenology Staff Meeting
*Secretary*, Dr. C. B. Peirce, University Hospital, Ann Arbor, Mich.
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Roentgen Club
*Secretary*, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis.
Meets monthly on last Thursday, October to April, Service Memorial Institute, at 4:30 P.M.

Virginia Roentgen Ray Club
*Secretary*, Dr. V. W. Archer, University Hospital, University, Va.
Meets annually in October.

### Cuba

Sociedad Cubana de Radiologia y Fisioterapia
*Secretary*, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

### British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1, or as advertised.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine, 1, Wimpole St., London, W. 1.

Section of Radiology and Medical Electricity, Australasian Medical Congress
*Secretary*, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
*Secretary*, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to Nov. incl. for scientific discussions.

Section on Radiology, Canadian Medical Association
*Secretary*, Dr. A. H. Rolph, 160 St. George St., Toronto, Ont.

Radiological Section, New Zealand British Medical Association
*Secretary*, Dr. P. C. Fenwick, The Hospital, Christchurch. Meets annually.

### Continental Europe

Belgian Society of Roentgenology
*Secretary*, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Sociedad Española de Radiologia y Electrologia
*Secretary*, Dr. J. Martin-Crespo, Fuencarral, 7, Madrid, Spain. Meets monthly in Madrid.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
*Secretary*, Dr. Walter Altschul, German University, Prague, II.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
*Permanent secretary*, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgengesellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

Societa Italiana Radiologia Medica
*Secretary*, Professor M. Ponzio, University of Turin, Turin.

Societatea Romana de Radiologie si Electrologie
*Secretary*, Dr. G. Gatoschi, Str. Isvor 14–16, Bucarest.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
*Secretaries*, Drs. S. A. Reinberg and S. G. Simonson.
Meets annually.

Leningrad Roentgen Ray Society
*Secretaries*, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
*Secretaries*, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

Polish Society of Radiology
*Secretary*, Dr. Jan. Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
*Secretary*, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
*Secretary*, Dr. G. Biering, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6.30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

### Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

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# ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

## ROENTGEN DIAGNOSIS

### ABDOMEN

Schilling, C. Magenulkus und Magenmechanismus im Röntgenkymogramm. (Gastric ulcer and gastric movements in the roentgen kymogram.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Jan., 1935, *51*, 29.

From the results of kymographic investigation Schilling draws the following conclusions.

(1) The normal mobility of the stomach is made up of active peristalsis, the passive movements of the proximal portion of the stomach and the systolic contraction of the whole viscus. All three components make up a definite characteristic movement.

(2) In the kymogram the functional movements stand in the foreground and in pathologic conditions one can differentiate direct from indirect disturbances of movement. In ulcer there are these direct signs: local loss of movement and interruption of peristalsis; and these indirect signs: alterations in peristalsis (along the greater and lesser curvatures), variations in tonus and filling and the changes produced by them.

(3) Functional changes caused by gastric ulcer are characterized by changes in the general mobility of the stomach, hyperperistalsis, depending on the location and size of the ulcer as well as secondary effects from functional peculiarities in neighboring organs.

(4) Kymography permits an exact analysis of the changes in gastric mobility, a differentiation of changes in its tonus and an exact study of changes in peristalsis.—*E. T. Leddy.*

Pape, R. Auffällige Röntgenbefunde bei achylischer Chloranämie. (Peculiar roentgenologic findings in achylic chloranemia.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Jan., 1935, *51*, 39.

In 3 cases of so-called achylic chloranemia Pape found an unusual roentgen appearance of the stomach. One case showed a high grade diffuse chronic hyperplastic gastritis with marked hypoacidity. In 2 cases which were operated on there were pseudo-defects which could be differentiated from neoplasm by their sharp delimitation, lack of degeneration and with a superficial extension. A knowledge of these changes is important for in the author's cases there were occult melena, marked secondary anemia, gastric distress, a resistance in the vicinity of the stomach and a defect in the roentgenogram similar to that of neoplasms. In all 3 cases a peptic ulcer had been present.—*E. T. Leddy.*

LINS, AGUINALDO. Sindroma da gastro-piloro-duodenite sem ulcus. (Syndrome of gastro-pyloro-duodenitis without ulcer.) *J. dos clin.*, No. 22, 1933.

After the roentgen era began and lesions of the stomach and duodenum could be demonstrated objectively, dilatation of the stomach was thought to be always the result of ulcer of the pylorus or stenotic ulcer of the duodenum (American idea)—"obstructive duodenal ulcer."

But the modern studies of Forssell, Berg, Chaoul and others on the gastroduodenal mucous membrane have shown that gastritis or gastroduodenitis may exist alone as well as accompanied by ulcer. One of the chief symptoms is dilatation of the stomach caused in the majority of cases by stenotic pyloritis.

This new clinical syndrome described recently by Manoel de Abreu throws new light on the interpretation of the roentgen signs of gastro-pyloro-duodenal affections. He has shown that changes in the pyloric mucosa are almost constant in gastroduodenal affections and that the clinical symptomatology depends primarily on a process localized in the mucosa and submucosa of the sphincter. When there is perfect elasticity of the mucosa and submucosa the caliber of the pylorus varies constantly. If the pylorus is infiltrated and rigid it varies little or not at all.

In order to form a reliable judgment in regard to the condition of the pylorus it is necessary to investigate its diameter, appearance, folds, its vase-shaped termination in the antrum and bulb and elasticity and to examine the pyloric border of the bulb of the duodenum. When the mucosa and submucosa are inflamed, congested and infiltrated the pylorus is long, narrow and sinuous with a deviated prepyloric or duodenal implantation. This is the appearance which characterizes organic inflammation. As the pyloric canal is the narrowest part of the gastrointestinal tract it is clear that chronic inflammation of the mucosa and submucosa will cause early and violent changes in the passage of food from the stomach to the duodenum, and Manoel de Abreu says that roentgen examination shows that pyloritis alone without spasm is the cause of most dilatations of the stomach.

The syndrome of gastritis without ulcer, very similar clinically to that of gastroduodenal ulcer, or even identical with it is as follows: (1) Frequently liquid in the jejunum; (2) thick prominent folds of the mucosa; (3) hardening and loss of elasticity of the mucosa; (4) irregular sinuousness of the surface of the mucosa; (5) special appearance of the mucosa in certain cases: areolar, granular, mammellonated, polypous; (6) variable malformations of the bulb of the duodenum, with absence of niche, radiating system of folds and the appearance of stenosis of the bulb; (7) in some cases propagation of the inflammation along the superior and descending part of the duodenum, with modification of Kerkring's folds; descending duodenitis; (8) emptying of the stomach generally retarded; (9) diffuse sensitiveness to pressure in the epigastrium or localized in the antro-pyloro-bulbar region.

The modern roentgen technique for the study of these conditions is to use a thick barium suspension in very small amounts, not more than 100 c.c. This should be swallowed slowly under screen control. Serial roentgenograms should be taken with various incidences of the rays, tangent and vertical. Examinations should be made at various times in order to follow the course of the disease.

Gastro-pyloro-duodenitis without ulcer as well as with ulcer may be so severe as to require partial gastroduodenectomy.—*Audrey G. Morgan.*

SORKIN, S. Z. Die Röntgenkymographie des Bulbus duodeni. (Roentgen kymography of the duodenal bulb.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Jan., 1935, *51*, 35.

From a study of 30 normal cases Sorkin concludes: (1) Opening of the pylorus is caused by gastric systole; closing of the pylorus is caused by gastric peristalsis. (2) The emptying of the duodenal bulb is divided into two phases: a rapid systolic emptying which is followed by a slower contraction of the walls of the bulb. (3) The bulb never completely empties itself, there is always some residual content. (4) The opaque meal is pressed out of the bulb in squirts. (5) The opaque meal passes through the rest of the duodenum by peristalsis of the duodenum. (6) The frequency of bulbar emptying is half that of gastric peristalsis and equal to that of closing of the pylorus.—*E. T. Leddy.*

PREVOT, R. Zur Röntgendiagnostik des übernähten perforierten Duodenalgeschwürs. (The roentgen diagnosis of sutured per-

forated duodenal ulcer.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, March, 1935, *51*, 273.

The present paper is an extension of one by Pich (*Bruns' Beiträge*, vol. 159, page 346) on the results of suturing perforated gastric and duodenal ulcers. Roentgenologic examination carried out about four weeks after operation showed the suture in most cases. The changes due to it are characterized by an inverted pouch of mucous membrane. Occasionally stenosis could be demonstrated. Stenoses caused by swelling of the mucous membrane clear up under treatment; if they persist they should be resected.—*E. T. Leddy.*

Gråberger, Gösta. Beitrag zur Kenntnis des Röntgenbildes bei Pneumatosis cystoides intestinorum. (The roentgen picture in pneumatosis cystoides intestinorum.) *Acta radiol.*, 1935, *16*, 439–444.

Pneumatosis cystoides intestinorum is an unusual disease in man characterized by the presence of multiple vesicles filled with gas along the course of the intestine. The clinical picture is not characteristic, but the author thinks roentgen diagnosis is possible in at least some of these cases which have heretofore been diagnosed only on the operating table or at autopsy. When the patient is examined in a standing position the gas-filled vesicles naturally rise and in some cases bring about the interposition of movable parts of intestine between the liver and diaphragm. He describes a case of this own in which the diagnosis was not made during life. Roentgen examination showed stenosis of the pylorus from ulcer, which was confirmed on operation; the operation also showed, however, a typical pneumatosis along about 50 cm. of the lower ileum. On reviewing the roentgenogram he thinks a diagnosis of the pneumatosis might have been made also if that condition had been thought of. In the left flank between the crest of the ilium and the costal arch there was an area about the size of the palm of the hand with a peculiar alveolar structure. The complete absence of the relief caused by Kerkring's folds and haustration in this region showed that the gas was not in normal intestine.

As pneumatosis shows a tendency to spontaneous recovery operation should not be performed except on definite indications.—*Audrey G. Morgan.*

Da Empoli, Giovanni. La tubercolosi intestinale, a tipo ulcero-cicatriziale, nei rapporti della tubercolosi pulmonare. (Intestinal tuberculosis of the ulcero-cicatricial type and its relation to pulmonary tuberculosis.) *Arch. di radiol.*, 1934, *10*, 481–516.

In the diagnostic Institute of Reggio, Italy, in which the author works, systematic roentgen examinations of the intestine have been made in all cases of pulmonary tuberculosis and a very large percentage of them have been found to have tuberculosis of the intestine. Postmortem pathological examination shows involvement of the intestine in 60–70 per cent of the cases and roentgen examination reveals it in 30–50 per cent of the cases. Clinical symptoms such as diarrhea and dyspepsia indicate involvement of the intestine and in such cases careful roentgen examination should be made as early diagnosis makes treatment possible at a stage when it may be effective.

Four cases are reported and illustrated with roentgenograms. Irregularity of passage of the contrast medium, sometimes retarded, sometimes hastened, and sometimes with alternating dilated and contracted portions, giving a rosary-like picture, associated with spots from retention of barium are very suggestive. The ileocecal region is most frequently affected by tuberculosis. Functional irregularity of the last loop of the ileum with scanty and irregular filling and insufficiency of the ileocecal valve indicate structural changes in the mucosa due to tuberculosis. Serial roentgenograms of the mucous membrane relief are of value in demonstrating the disease. The appendix is generally impervious, sometimes partially pervious with irregular filling. The part of the intestine that is affected can be determined by roentgen examination.—*Audrey G. Morgan.*

Crawford, Paul M., and Sawyer, Harold P. Intestinal tuberculosis in 1,400 autopsies. *Am. Rev. Tuberc.*, 1934, *30*, 568–583.

In view of the variance of figures in the literature as to the incidence of tuberculous disease of the intestinal tract, a survey of the material furnished by 1,400 autopsies at Fitzsimons General Hospital is given.

In this series, 68.8 per cent of cases of fatal phthisis showed ulcerative tuberculous intestinal lesions. Ulcerative intestinal tuberculosis was found as a complication of tuberculous pulmonary disease in 87.5 per cent of the colored

race, as against 42.2 per cent in the whites. In 540 cases of intestinal tuberculosis complicating pulmonary tuberculosis, 53.7 per cent occurred in cases with pulmonary symptoms having a duration of six months to three years. In 34 per cent the intestinal lesions were asymptomatic and in 35 per cent the duration of enteric symptoms was less than six months.

Tuberculous laryngitis occurred in 36.6 per cent of cases of intestinal tuberculosis, but 96.6 per cent of cases of tuberculous laryngitis showed intestinal ulceration.—*L. H. Osmond.*

REBUSTELLO, EUGENIO. Ricerche radiografiche sulla vascolarizzazione sanguifera della valvola ileo-cieco-colica dell'uomo. (Roentgen study of the vascularization of the ileocecocolic valve in man.) *Arch. di radiol.*, 1934, *10*, 593.

The author describes and illustrates the blood supply of the ileocecal valve. Among the branches of the ileo-ceco-appendiculo-colic artery there is very frequently one which is called the common cecal artery, from which the anterior and posterior arteries originate, or there may be three branches, two of which run on the posterior surface of the cecum and one on the anterior surface, or vice versa, one on the posterior surface and two on the anterior. There are variations in the number and course which have been noted by other authors.

The common cecal artery furnishes delicate branches which run in the subperitoneal tissue of the region or to the lymph nodes of the ileo-ceco-appendiculo-colic chain; sometimes the common cecal artery gives rise to a branch which anastomoses with the ileal artery, running inside the median margin of the last portion of the ileum and which must not be confused with the cecoileal anastomotic branch.

Often there are two types of distribution of the cecal artery which the author calls the fan type and the disperse type. In either case at the level of the cecocolic sulcus there is a large number of small arterial and venous branches which when they are injected form a very intense vessel shadow. There is almost always an anastomotic tract originating from a branch of the cecal artery and the trunk of one of these arteries running toward the ileum and along the free margin of its last portion and anastomosing with the ileal branches of the ileo-ceco-appendiculo-colic artery. Often instead of a single cecoileal anastomotic branch there are two.

In addition to the branches which are distributed to the walls of the cecum, the cecal arteries give rise to valvular branches which run in the lips of the ileo-ceco-appendiculocolic valve, which is vascularized solely by these branches. The valvular branches of the arteries in the lips of the valve are arranged in a tuft; they intertwine in various ways with a serpiginous course, or they may, like the venous branches, form a crown inside the margins of the valve.

The roentgen picture of the ileocecocolic valve is very different in roentgenograms made after injection of the arteries alone and those made after injection of both arteries and veins. In the former the picture is indistinct, while in the latter it is very distinct and the shape of a cupola. The valvular veins are more numerous and larger than the corresponding arteries, and anastomosing with each other they form a crown inside the margins of the valve.—*Audrey G. Morgan.*

BIGNANI, G. Sulla diverticolosi del colon. (Diverticulosis of the colon.) *Arch. di radiol.*, 1934, *10*, 517–531.

Two cases of diverticulosis of the colon are described and illustrated with roentgenograms. The most characteristic clinical features were alternating periods of constipation and diarrhea and the passage of small hard round balls of feces, apparently due to feces having stagnated in the diverticula and then being passed in this form. In the first case the roentgenograms showed characteristic spots of contrast particularly along the descending colon where the diverticula were most numerous. In the second case only a few diverticula could be seen along the transverse and descending colon. It is possible that there was diverticulitis of other diverticula that prevented their filling with the contrast medium. In the first case the patient had copious hemorrhage, probably due, the author thinks, to congenital changes in the vessels. He believes that these cases of diverticulosis of the colon are more frequently congenital than is commonly thought. These diverticula may remain latent clinically unless they become inflamed and the only means of diagnosis is by roentgen examination.—*Audrey G. Morgan.*

GILBERT, R., JUNET, R., and KADRNKA, S. Comportement du foie et de la rate vis-a-vis des radiations de roentgen après introduc-

tion intraveineuse de thorotrast. (Reaction of the liver and spleen to roentgen irradiation after the intravenous injection of thorotrast.) *Acta radiol*, 1935, *16*, 445–455.

The author irradiated the region of the liver and spleen in rabbits after they had been given intravenous injections of colloidal thorium. The control animals were either irradiated without being given thorotrast or given thorotrast without being irradiated.

Cells containing thorotrast granules appeared much more quickly in the follicles of the spleen in the animals irradiated with doses of 1,800 r by simple fractionating than in the non-irradiated animals. The passage of the particles of thorium from the reticulo-endothelial cells to the lymph of the follicles of the spleen was therefore accelerated by the irradiation. This acceleration of filtration was much less marked in the liver.

In some of the rabbits, irradiation of the liver with a dose of 2,800 r by protracted fractionating after the injection of thorotrast brought about a much greater degree of change in the liver cells than in the animals that were not injected. The presence of thorium in the Kupffer cells therefore seems to sensitize the liver cells of the rabbit to roentgen irradiation, possibly by additional secondary irradiation from the particles of metal. This action was not observed in the spleen with the same dose.—*Audrey G. Morgan.*

Rosser, Curtice. Cancer of the anal canal; a survey of 25 cases. *South. M. J.*, June, 1935, *28*, 527–529.

The author analyzes a ten year group of 25 cases of neoplasm in the anal canal. Fifty-six per cent were found to be under the age of fifty-one, 84 per cent had associated benign lesions, while pain was present in practically all cases, being the presenting symptom in 60 per cent of the patients. Both squamous and adenocarcinoma were found, either above or below the dentate line. Perineal resection gave 6 alive and well out of 10 cases, while the record of irradiation shows recurrences in 8 of 9 cases. Three of these cases, however, had relief from one and one-half to four and one-half years. Deep roentgen therapy is effective in controlling inguinal metastases. Colostomy would have contributed to the comfort of several of the patients who received irradiation.—*W. R. Brooksher.*

Gerth, F. Zur Frage der sog. "Pseudozysten" des Pankreas. Bursitis omentalis. Anatomische und röntgenologische Befunde. (The question of so-called "pseudocysts" of the pancreas. Bursitis omentalis. Anatomic and roentgenologic findings.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Jan., 1935, *51*, 8.

Gerth describes a peripancreatic cyst which had reached the size of a man's head and which involved the lower portion of the pancreas and which was due probably to a chronic omental bursitis which caused a local necrosis of the tail of the pancreas seven years previously. The cyst was demonstrated roentgenographically two years before the death of the patient but the diagnosis was not made definitely. The autopsy and clinical findings are compared and discussed. The patient also had diabetes and a short time before death there was a perforation of the cyst into the small intestine. The author discusses a case with similar clinical, operative and roentgenologic findings but without autopsy control.—*E. T. Leddy.*

Young, John S. Cholecystitis; tetraiodophenolphthalein in the treatment of certain selected cases. *J. Missouri M. Ass.*, Sept., 1935, *32*, 375–377.

Tablets containing 3 grains of tetraiodophenolphthalein sodium were given three times daily, one-half to one hour before meals, until 30 were taken by patients with known pathological gallbladders. Following a few days' wait, a roentgen examination was made. The mucosal function of the gallbladder was improved in all instances, except only in those cases which were purely surgical or malignant. Sixteen cases are reported.—*W. R. Brooksher.*

Schéle, Åke. A contribution to the roentgen diagnosis of gallstone ileus. *Acta radiol.*, 1935, *16*, 456–460.

After a review of the cases described in the literature the author reports a case of gallstone ileus diagnosed by roentgen examination which showed a typical picture with (1) a fistulous communication between the gallbladder and duodenum and (2) a foreign body impacted in the small intestine, in this case in the upper part of the jejunum, which had caused a dilatation of the proximal part of the small intestine and of the stomach.—*Audrey G. Morgan.*

ZIMMER, A. Zur Erkennung und Bewertung von Darmanastomosen im Röntgenbilde. (The roentgenologic recognition and estimation of intestinal anastomoses.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Feb., 1935, *51*, 169.

Zimmer discusses the various types of intestinal anastomoses and points out that it is difficult roentgenologically to recognize an end-to-end union. He illustrates the findings in 8 cases and explains the differential diagnoses.—*E. T. Leddy.*

GIBSON, COLE B. Calcified abdominal lymph nodes. *Am. Rev. Tuberc.*, 1934, *29*, 447–460.

In a group of 200 children abdominal roentgenograms have brought to light 19 patients with calcified abdominal lymph nodes. For varying periods and for various reasons these children have been under definite suspicion for tuberculosis. In 5, undoubted tuberculosis has been demonstrated. The remaining 14 were not clear cut. History of interrupted physical progress, indefinite symptomatology, positive tuberculin reaction, and lack of proof of any other existing disease were responsible for the attitude that each probably had tuberculosis or was undergoing the effects of first infection with tubercle bacilli. The evidence revealed by the abdominal roentgenograms serves to validate their suspicions in these cases and also points a significant finger toward others.

It is to be remembered that tubercle formation and caseation in lymph nodes may proceed for some time, and although strong suspicion may exist the diagnosis must be deferred until calcification begins and is demonstrable on the roentgenograms. Moreover, it is well known that the node in question may still contain caseating portions and therefore be potentially dangerous.—*L. H. Osmond.*

## GENITOURINARY SYSTEM

JANSSON, GÖSTA. Die Röntgendiagnose bei Nierenbeckenpapillom. (Roentgen diagnosis of papilloma of the kidney pelvis.) *Acta radiol.*, 1935, *16*, 354–360.

Papillomata of the kidney are quite rare and very difficult to diagnose clinically. There is copious hemorrhage, painless, and beginning and ending suddenly without apparent cause. Palpable resistance rarely occurs. Repeated copious hemorrhage without palpable tumor is very suggestive of papilloma of the pelvis. The cases are so few that there has been no complete review of the roentgen findings. The author thinks it important therefore that the findings be registered in all cases.

He describes 2 cases of his own and illustrates them with roentgenograms. The changes, of course, vary with the size and structure of the tumor and the nature of the tumor bed. Sometimes the tumors consist of small grape-like structures but sometimes they consist of papillomatous masses that fill the whole pelvis. If they are small and sessile, defects occur in the filling of the pelvis which project into the lumen of the pelvis and show a wavy contour indicating a nodular surface. In these cases it may be hard to make a differential diagnosis from a tumor of the parenchyma which has ruptured into the pelvis. But a tumor of the parenchyma of that size would probably be palpable and would have produced the other changes in the pyelogram characteristic of this kind of tumor. Most of the pyelograms of papilloma described in the literature belong to this type.

Another form is diffuse papillomatosis in which the pelvis is filled with cauliflower-like masses; multiple defects are seen in the filling of the pelvis and there are irregular clear spots. Some of them, like the author's first case, have a sharply rounded form. If the whole pelvis is filled with a villous tumor the appearance of the pyelogram is determined by the amount of contrast fluid which is able to penetrate between the villi. The branches of the papilloma often fill the calyces so that the contrast fluid cannot enter them and they do not appear on the pyelogram. A similar picture may also be produced by blood clots in the pelvis. If the villi form a solid mass the pelvis may not fill at all or perhaps only a single calyx is filled. These pictures resemble those of advanced tumor of the parenchyma. This second type of pyelogram with multiple irregular or rounded intrapelvic defects is considered by the French as characteristic of papilloma of the kidney pelvis.

A third type is that seen in the author's second case. A single pedunculated tumor the form of a polyp causes a spindle-shaped rounded defect with a reticulate inner structure which distinctly shows the nodular surface of the tumor. Repeated examinations in such cases may show that the tumor is movable. Any form of papilloma may temporarily obstruct the opening of the ureter and cause dilatation of the pelvis.

In the first edition of Schinz' Handbook he says: "Papillomata of the kidney pelvis are not adapted for pyelographic demonstration for in the beginning they do not cause any filling defects and when they can be demonstrated they have caused such copious hemorrhage as to attract attention." But the author holds that while roentgen demonstration of beginning papillomata of the pelvis may be difficult it is of great importance and not impossible. Uroselectan and perabrodil may be used for thin layers of contrast in retrograde pyelography and have no bad by-effects. It is sometimes possible to demonstrate a small papilloma with a thin layer of contrast that would be lost in a filled pelvis.—*Audrey G. Morgan.*

Lenk, R. Die Röntgendiagnose der blasigen Erweiterung des vesikalen Harnleiterendes. (Roentgen diagnosis of cystic widening of the lower end of the ureter.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, April, 1935, *51*, 391.

The author describes the roentgenologic characteristics of cystic dilatation of the ureter. He points out the great diagnostic value of a clear ring surrounding the cyst after filling by contrast medium.—*E. T. Leddy.*

SKELETAL SYSTEM

Smith, Frank L., and Rider, Dean L. A study of the healing of one hundred consecutive phalangeal fractures. *J. Bone & Joint Surg.*, Jan., 1935, *17*, 91–109.

The authors' report is based upon the study of 100 consecutive fractures of the phalanges. They divide the fractures into the following types:

A. Transverse or splitting fractures of the distal, middle and proximal phalanges; B. Chip fractures of (1) tip of distal phalanx, (2) interphalangeal joints. Further subdivision was then made into (1) complete, (2) incomplete or fissured, (3) ununited, and (4) badly lacerated or compound fractures. In this last group infection and devitalized tissues played an important part in the ultimate result.

Their conclusions are as follows:

1. The average time for bony healing of complete phalangeal fractures of all types, as shown roentgenographically, is approximately five months.

2. Clinical healing requires about one-fourth of the time required for roentgenographic healing.

3. The fracture lines are usually more distinct at the end of thirty days than at the time of injury.

4. Single or multiple chip fragments in the tips of the distal phalanges practically always reunite and give a normal-appearing contour of the distal phalanx.

5. No callus is seen in a chip fragment at the tip of the distal phalanx and there is more callus formation in the proximal phalanges.

6. In none of these cases has there been absorption of any of the loose fragments.

7. It cannot be assumed that there is a lack of bony union until at least one year has elapsed.

The paper is profusely illustrated with roentgenograms of these various types of fracture, showing the stages of healing, the end-results, etc.—*R. S. Bromer.*

Aitken, Alexander P. The end results of the fractured distal radial epiphysis. *J. Bone & Joint Surg.*, April, 1935, *17*, 302–308.

Few reports have been published in the literature on the end-results of the separated distal radial epiphysis. Aitken's series consists of 8 female and 50 male patients. The former varied from nine to sixteen years of age while the latter ranged from four to eighteen years. In 2 cases the injury was bilateral; one case was reversed in type to the usual deformity, i.e., anterior displacement, with a chip off the anterior lip of the radius; the posterior edge of the diaphysis was fractured in 26 cases, the ulnar styloid in 19, and in 12, both these structures were fractured. In 2 cases the ulnar epiphysis was displaced dorsally. In the cases of fracture of the ulnar styloid in addition to the radial epiphysis injury, there was one case in which solid union with the shaft occurred, in 2 cases there were no remains of the ulnar styloid, and in the remaining 16 there was definite displacement of the fragment with no bony union as shown by late roentgenograms.

Malposition does not persist. Within a maximum of two to three years, Aitken found that the epiphysis had again assumed its normal relationship to the shaft. This fact obviates the necessity of repeated manipulations in order to secure accurate reduction. It also eliminates the use of osteotomy for reduction.

Premature ossification and retardation of growth occur frequently, but in the large percentage of cases these factors are clinically negligible. There will be an occasional isolated

case which will show definite interference of growth with deformity. This is due to damage done at the time of injury.

Ossification of the radial epiphysis apparently starts in the ulnar half of the epiphysis.

Repeated manipulation adds little, if any, to the trauma done to the epiphysis. Most of the poor end-results are due to severe crushing trauma received at the time of injury.—*R. S. Bromer.*

MACAUSLAND, ANDREW R. Separation of the capital femoral epiphysis. *J. Bone & Joint Surg.*, April, 1935, *17*, 353–369.

The lack of end-result studies in the literature on the subject of slipping capital femoral epiphysis, and the question of the efficacy of the closed reduction in treating this lesion induced MacAusland to make this study. His series of cases numbered 45.

The treatment of a slipped epiphysis varies with the stage of the lesion. In the mild case, of which there were 2 in his series, the leg is protected by a flannel bandage or spica. Early cases of slight or moderate displacement and recent cases of severe displacement due to trauma are treated by the Whitman method. Accurate reduction of the epiphysis has been made possible by the introduction of the curved cassette of Leonard and George. Following reduction, the hip is fixed in full abduction, hyperextension, and moderate internal rotation by means of a plaster spica. This must be worn until firm union has taken place; in the author's opinion, a period of six months is required for the structures to consolidate. Weight-bearing, so far as it can be obtained with the leg in the abducted position, is allowed during the period of immobilization. Following the removal of the plaster spica, a flannel bandage is worn for three months, and physiotherapy and exercise are instituted to restore the muscle power.

Advanced cases in which ossification between the displaced epiphysis and the neck has taken place, and in which new bone has formed to a great extent, call for open reduction. Operative treatment is also indicated in cases in which the femoral head has flowed around the neck, so that the hook on its end is beyond 30 or 40 degrees. In long standing cases of solid union with coxa vara, in which even approximate restoration of the joint surface is impossible, deformity may be corrected by a wedge osteotomy. Finally, there is the long standing case in which no treatment has been received or in which the treatment has been inefficient. The slipping has progressed in these cases until complete separation has occurred, or until repair has taken place with the hip in flexion-adduction deformity. Arthritic changes may be present as the result of interference with function. A chronic back strain or mild curvature may develop. Occasionally a complete ankylosis of the hip joint is seen. The treatment of this last class depends upon the extent, etc., of the pathological changes. At times, a reconstruction operation, an arthrodesis, or an arthroplasty is indicated. The adult patient with secondary arthritis presents a particular problem from a therapeutic standpoint, as conservative measures afford only temporary relief and such patients are usually poor operative risks.

Closed manipulative reduction proved efficacious in a series of 29 cases. In 80 per cent of these patients, excellent or good functional results were obtained; in 8 per cent, the functional results were fair. Successful treatment by the closed reduction depends upon early institution of treatment, accomplishment of complete reduction, and active treatment for a sufficiently long time.—*R. S. Bromer.*

BROGDEN, W. E. Review of the end results of fifty-seven cases of slipped upper femoral epiphysis. *J. Bone & Joint Surg.*, Jan., 1935, *17*, 179–183.

Brogden's especial interest in the subject of slipped upper femoral epiphysis was aroused by a so-called "run" of cases of this character; by the fact that a large percentage of the cases so diagnosed were found to be in the thin, tall type of individual, with no evidence of disease or disturbance of growth; by the fact, also, that in the majority of cases there was a definite history of trauma with immediate onset of disability. He noted, too, that whether or not a good open or closed reduction had been attained, the postoperative roentgenogram seemed to bear no relation to the functional end-result.

Some of his conclusions after a review of the literature are as follows:

Regardless of sex, the left hip was affected twice as frequently as the right. There is no doubt that rickets, osteomalacia, or osteochrondritis plays a part as a predisposing factor in some cases, but on the other hand, a large percentage of the patients had a definite history

of injury. Probably trauma as the sole causative factor in the production of the condition plays a more important rôle than is usually supposed. Unilateral epiphyseal fracture or coxa vara in normal healthy individuals is usually the direct result of injury; while in cases of bilateral epiphyseal fracture there is usually a constitutional predisposition to displacement. A year or eighteen months is not a sufficient lapse of time to permit a definite statement as to the functional end-result. The postoperative roentgenogram is not a criterion of the end-result. Perfect reposition of the head on the neck does not insure normal growth. Abnormality of growth or endocrine imbalance, either separately or in conjunction, were designated as predisposing etiological factors in 34 of the 57 cases reviewed. Traumatic arthritis was seen to develop more frequently in the patients subjected to open operation.

It is Brogden's belief that all cases are entitled to the benefit of the doubt and that an attempt at closed reduction should be made if disability is of less than four months' duration. If this fails, an open operation should be performed. In all cases of over four months' disability the patients are entitled to an open operation as a primary procedure except in selected cases.—*R. S. Bromer.*

Carlucci, Gaston A. Osteochondroma of the femur. *J. Bone & Joint Surg.*, Jan., 1935, *17*, 204–208.

Carlucci reports a case of osteochondroma of of the femur in a female patient, aged sixty-four. The tumor was about the size of a football and had practically replaced all of the tissues in the lower half of the thigh. She apparently had had this tumor for well over twenty-five years and, in spite of her age and diabetic condition, she was able to withstand a high mid-thigh amputation and the wound healed firmly. The amputation was justifiable because the pain in the knee had become unbearable in spite of all medication. At the time of amputation the specimen was carefully studied for any possible malignant changes, but none were found. In spite of amputation well above the level of the tumor, eight months after operation an extremely malignant osteogenic sarcoma developed at the end of the femoral stump, which caused the patient's death within two months. —*R. S. Bromer.*

Gottlieb, F. Semnul ischio-pubeean in profilaxia luxatiei şoldului zisă congenitală. (The ischial-pubic sign in the prophylaxis of so-called congenital subluxation of the hip.) *Primul Congres Naţional de Radiol. şi Electrol. Med.*, Bucureşti, October 26–28, 1934, Comunicări, pp. 8–12.

Lorenz, in his fundamental work which appeared in 1920, states that the subluxation of the hip is an acquired static deformity due to pressure of the body weight on the union of the hip bones. According to this theory only the predisposition is congenital, consisting in a delay of development of the bones of the entire inferior extremity and the corresponding half of the pelvis, especially of the acetabulum. The author since 1929 noticed a roentgen sign which he called the ischial-pubic sign and which is a proof of the delay of bone development, thus indicating the predisposition to subluxation. The sign consists in a separation of the ischial-pubic bones on the affected side as compared to the opposite normal side where the union due to normal development of the bones is more advanced. The author followed a series of clinical observations on children who did not as yet walk and he found that a careful palpation of the ischial-pubic rami permits the detection of a variation in thickness of the ischial-pubic arch, this being considerable thinner than on the opposite normal side. From this he arrives at the conclusion that the demonstration roentgenologically of an ischial-pubic separation and clinically of a thinning of the ischial-pubic arch are indicative of a congenital predisposition of a unilateral dislocation of the hip. He recommends that every child, and especially girls, be examined before walking by the two methods and in case that a predisposition is established a preventive treatment for the dislocation be immediately started. The only one criticism of the method is that it cannot always be applied in case of bilateral involvement, but apart from the fact that such a condition occurs rarely there is always some inequality of the process on the two sides which permits an approximate diagnosis. Furthermore it is conclusively demonstrated that in more than 25 per cent of the unilateral cases some deviation from the normal is observed also on the supposedly undiseased side.—*T. Leucutia.*

ILIESCU, N. C. Consideraţiuni radiologice asupra maladiei Calvé-Legg-Pertes. (Roentgen considerations of Calvé-Legg-Perthes' disease.) *Primul Congres Naţional de Radiol. şi Electrol. Med.*, Bucureşti, October 26–28, 1934, Comunicări, pp. 15–18.

After considering the nature, anatomopathologic aspect, and evolution of Calvé-Legg-Perthes' disease, the following criteria are discussed from the point of view of differentiation from tuberculosis: (*a*) decalcification does not appear at more distant points as is observed in tuberculosis. (*b*) There is lack of osseous atrophy. (*c*) The interarticular space is enlarged and its transparency is relatively well preserved. (*d*) The nodules of sharp osseous ulceration as observed in tuberculosis are lacking. (*e*) The femoral head, although fragmented, shows a sharp contour whereas in tuberculosis the contour is less defined. (*f*) In suppurated and secondarily infected tuberculosis there usually appear osteophytic processes which are always missing in Calvé-Legg-Perthes' disease. —*T. Leucutia.*

WEAVER, JAMES B. Ossification of the internal semilunar cartilage. *J. Bone & Joint Surg.*, Jan., 1935, *17*, 195–198.

Weaver was able to find in the literature only 4 cases of ossification of the semilunar cartiages, 2 in the internal and the other 2 in the external. He adds one case of his own. The patient, a white male, aged twenty-four, suffered a trauma twenty months before admission to the hospital, his right knee having been jammed against a corral fence while riding horseback. He had immediate pain and edema which were not severe enough, however, to keep him off his feet and which subsided in a few days. The symptoms persisted, at first in mild degree but later more and more severe until six months before his admission he had become practically incapacitated. At the time of admission he had atrophy of 1 inch in the right thigh, no shortening, limitation of motion in the knee joint, the latter being painful. There was a sense of fullness on the lateral side of the knee joint at the site of the infrapatellar ligament but no palpable mass. There was no hydrops, increased heat or discoloration of the skin. A roentgenogram showed calcareous deposits in the anterior portion of the knee joint.

At operation, a small encapsulated tumor was found at the upper, anterior end of the tibia and homogeneous with the internal semilunar cartilage, adherent to the capsule. This had made a small depression in the tibia. The tumor was easily removed, recovery was uneventful and a complete return of function was secured.

Weaver considers his case a true heterotopic bone formation. His case had both calcium deposition and new bone formation, thus having all steps in heterotopic bone formation as outlined by Leriche and Policard—namely, trauma, irritative inflammation, reversion of connective tissue to embryonic state, calcification, irritation again, revascularization, and the formation of new bone.—*R. S. Bromer.*

KING, E. S. J. Osgood-Schlatter disease and patella partita. *J. Bone & Joint Surg.*, Jan., 1935, *17*, 88–90.

King draws attention to the fact that in numerous reported cases of osteochondritis of an epiphysis which formed one component of a joint, there were associated changes in other parts of the joint. Thus in the case of the upper femoral epiphysis, changes also occur in the acetabulum, the adjacent part of the diaphysis and at times, in the trochanters. In the knee joint, the bone most obviously involved is the patella (Larsen-Johansson disease). Concomitant changes in the lower femoral epiphysis usually have been overlooked or regarded as of little importance. The association of osteochondritis of the patella with Osgood-Schlatter's disease of the tuberosity of the tibia has been discussed by a number of writers. In several cases this association has been observed in the same limb and, in others, the patella of one side and the tuberosity of the tibia of the other were found to be involved.

Patella partita has been shown to have some relationship to osteochondritis. King reports a case of this associated condition in a boy, aged ten. The roentgenographic examination showed both osteochondritis of the anterior tubercle and a tripartite patella in the same leg. It has been suggested that the latter is a condition which predisposes to the development of osteochondritis, but King concludes that, at the present time, it is useless to postulate possible causes for the condition. Many more observations are necessary before any deductions of real value can be made.—*R. S. Bromer.*

GEORGE, RUGGLES. Bilateral bipartite patellae. *Brit. J. Surg.*, Jan., 1935, *22*, 555–560.

A patella in two parts is of interest in the differential diagnosis of fracture. It can be, theoretically, the result of either an ununited fracture or the failure of two ossification centers to fuse with each other. The author studied this anomaly microscopically and found certain points of interest.

The first point of interest concerned the articular cartilage covering each fragment. This showed no evidence of the repair that could be expected if there had been a fracture of the patella. There were no changes in the deeper layers of the articular cartilage and no substitution of connective tissue for cartilage to suggest an old fracture.

The second observation of interest was the histological picture of the gap between the bony portions. This gap was filled in with a type of connective tissue which demonstrated some of the features of both dense irregularly arranged fibrous connective tissue and cartilage. The area between the two bony portions suggested that the gap was the result of premature cessation of the spread of ossification from separate centers.

The bilaterality of bipartitism is once again stressed. The author also states that almost invariably the superolateral angle of the bipartite patella is separate from the main portion of the bone.

The article contains several excellent illustrations.—*P. J. Hodes.*

Hunter, Donald, and Wiles, Philip. Dyschondroplasia (Ollier's disease). *Brit. J. Surg.*, Jan., 1935, *22*, 507–519.

The authors define Ollier's dyschondroplasia as "a disease of the growing ends of bone in which the normal ossification of cartilage fails to take place, so that, as the bone increases in length, there remain in the diaphyses areas of cartilage which do not ossify. The process is not primarily one of tumor formation. . . ." Having defined the condition they point out that the etiology is unknown and report the findings in a boy seven years of age in whom the only finding on physical examination was shortening of the right leg. The interesting feature of the case is the definite involvement of most of the other bones on the right side of the body of which only the lower limb showed clinical evidence of disease.

The positive diagnosis of dyschondroplasia is made on three main points. First, the onset is in early childhood and there is no hereditary transmission of the disease. Second, the roentgenographic changes are limited to the ends of the long bones and are characterized by a translucent pyramidal area with its apex at the nutrient foramen and its base resting on the epiphyseal line. The area is divided into septa with fusiform enlargement of the diaphysis, the epiphysis being involved only secondarily. As the child grows older the striped appearance is lost and is replaced by a speckling. Third, histological studies of the translucent areas reveal their cartilaginous character.

The age of onset is unknown but some abnormality in growth is usually noticed during the first two years of life. As growth proceeds the difference in development becomes progressively greater. At the earliest stage only the diaphysis is involved but after about five years roentgenographic study will reveal some involvement of the epiphysis also. As the patient grows older areas of calcification appear in the affected areas. By the time the epiphyses would normally have united to the diaphysis the two present a uniform picture.

The article is well illustrated.—*P. J. Hodes.*

Livingston, S. K. Skeletal blastomycosis. *J. Bone & Joint Surg.*, April, 1935, *17*, 499–505.

The term "blastomycosis" has been applied to all suppurative granulomatous processes affecting the skin and internal structures, due to yeast-like fungi. The term is more correctly applied to cases characterized by the presence of granulomatous, verrucoid lesions in which fungi of the *Blastomyces* are found. These fungi may be considered to be of the genera, *Saccharomyces*, *Cryptococcus*, *Coccidioides*, *Oidium*, and *Monilia*. Some authors, however, are of the opinion that blastomycosis and coccidioidal granuloma are distinct clinically, pathologically and biologically. The histological features are: (1) a hyperplasia of epithelium reminding one of epithelioma; (2) small intra-epithelial abscesses; (3) a granulomatous appearance of the corium with collection of plasma cells, giant cells, small nodes, and abscesses, and (4) the abundant presence of the organism, especially in the giant cells and subepithelial abscesses. The sweat glands and hair follicles are imbedded in this granuloma which may extend to the muscular layer.

In most cases, the disease is chronic and lasts for years. The cutaneous lesions may have

periods of rapid progression, interrupted by periods of quiescence. They may exist for years without involvement of the deeper parts. In the systemic cases, the signs and symptoms may be similar to those of tuberculosis and pyemia. In some cases the onset is sudden with febrile disturbances and in others it is insidious. After the systemic disease has been established, the symptoms are malaise, loss of strength, emaciation, pain in the affected parts, irregular fever, rapid pulse, and occasional chills and sweating. Symptoms and signs of pulmonary involvement are commonly manifested. The fungi may be found in the sputum. As in other infections, there may be anemia and leukocytosis.

The accepted treatment includes iodides by mouth and intravenously. Autogeneous vaccines have been recommended. Radiation therapy in bone and skin lesions should be attempted.

In Livingston's case the patient was admitted with a diagnosis of osteosarcoma of the right tibia; this diagnosis was carried until the smear revealed the presence of blastomycetes. The portal of entry was unknown.

The roentgenograms showed an area of bone destruction on the border of the internal malleolus due to necrosis. There was enlargement of the soft tissues over this region. The bones of the pelvis showed evidence of a pathological process, characterized by destruction of bone tissue, in the region of the neck of the right femur, right ilium and both sacroiliac joints.

Livingston states in conclusion that blastomycosis of bone is usually a manifestation of systemic involvement; diagnosis is made by the identification of blastomycetes; tuberculosis, coccidioidal granuloma and blastomycosis produce the same pathological changes and pus from all chronic osteomyelitic lesions should be studied for the presence of blastomycetes.—*R. S. Bromer.*

LIVINGSTON, S. K. Hodgkin's disease of the skeleton without glandular involvement. *J. Bone & Joint Surg.*, Jan., 1935, *17*, 189–194.

Livingston reports the case of a white male, aged forty-one, in whom the roentgenograms showed an area of rarefaction in the left ischium which suggested metastatic or cystic degeneration; small, extensive, discrete, eroded areas throughout all portions of the skull which suggested a malignant process; no lesions in the long bones; no pathological changes in the chest. The autopsy showed Hodgkin's disease involving ribs, skull, pelvis, lumbar spine, and liver, without glandular involvement.

Bone marrow lesions of typical structure are observed in generalized Hodgkin's disease, but, as a rule, the cortical tissue and periosteum remain intact. Ziegler, however, believes that many peculiar osteal and periosteal lesions attributed to primary tumors of bone and marrow, or to obscure inflammatory processes, belong in this group, and he has collected a series of such cases, including myeloma with plasma cells, and lymphosarcoma, which he would class with Hodgkin's granuloma. Case reports of Hodgkin's disease confined to the skeleton, spleen or liver without lymphatic involvement are extremely rare. It is possible, Livingston concludes, that many peculiar osteal and periosteal lesions attributed to primary tumors, or to obscure inflammatory processes, belong to this group.—*R. S. Bromer.*

OBLU, I. Artritele gonococice (studiu radiologic). (Gonococcic arthritis; roentgen study.) *Primul Congres Naţional de Radiol. şi Electrol. Med.*, Bucureşti, October 26–28, 1934, Comunicări, pp. 23–24.

Sudden decalcification associated with precocious loss of the epiphyseal contour is characteristic of blennorrhagic infection. (2) Acute osteoporosis constitutes the initial lesion in many cases of acute blennorrhagic arthritis. (3) The attenuated osteoporosis with pearly appearance is observed nearly constantly in the chronic phase of blennorrhagic arthritis. (4) The decalcification as a rule appears regular whereas in tuberculosis it appears in the form of irregular foci. (5) One observes an atrophic lesion in blennorrhagia, constructive lesion in syphilis and necrosing lesion in tuberculosis. (6) Irregularity of the cartilaginous contour, decalcification of the superficial layers of the bone, irregularity or disappearance of the cortex with a clear appearance of the spongiosa is indicative of a blennorrhagic process. (7) Roentgen study is advisable during the course of treatment and for the establishment of prognosis in all cases of blennorrhagic arthritis. A sudden decalcification represents a serious prognosis whereas the demonstration of washed out contours, cartilaginous erosion and diminishing or narrowing of the joint space represent signs of a grave prognosis. On the other

hand, the appearance of recalcification constitutes a sign of convalescence. Furthermore, the roentgen examination helps to detect complications such as spontaneous subluxation, various sequelae (exostosis, osteitis, epiphyseal deformity, ankylosis, etc.). (8) A blennorrhagic arthritis without roentgen signs will lead, as a rule, to complete healing.—*T. Leucutia.*

McCune, Donovan J., and Bradley, Charles. Osteopetrosis (marble bones) in an infant. *Am. J. Dis. Child.*, 1934, *48*,949–1000.

McCune and Bradley review the literature of osteopetrosis (Albers-Schönberg's disease) and present a very complete summary of its historical, anatomic, chemical and clinical aspects. They tabulate 67 cases which have been reported, and present one of their own in detail.

There is no evidence at the present time to suggest that osteopetrosis is due to endocrine disturbance, according to the authors, or to environmental factors, dietary deficiency or chemical poisoning. Although it is possible that there are inconstant associated changes in the calcium and phosphorus metabolism, these alterations, if present, are probably secondary manifestations of a primary disturbance in the formation of bone. The Albers-Schönberg syndrome is a true developmental disease which consists in faulty differentiation of the primitive common forerunner of osteogenic and hematogenic tissue. The ultimate cause of the abnormality is unknown, but it seems to be a property of the parental germ plasm.

The discussion of the chemical composition of the bones, the clinical aspects of the disease, its pathologic changes, the metabolic studies, etc., are too voluminous to be briefly abstracted. The roentgenographic changes are described as follows:

I. Increased density of the entire skeleton.

A. Marked increase in density in the roentgen shadow of the skeleton with complete or partial loss of the normal structure of the bones. The shadow of the marrow cavity is reduced, sometimes to the point of complete obliteration. The most striking increase in density is in the vertebral bodies.

B. "Stratification" or the appearance of transverse bands of alternating greater and less density parallel to the epiphyseal line on the shafts of the long bones. These vary in width and number. They may be limited to the ends of the diaphyses or may be present through the whole diaphysis. The flat bones of the pelvis and the small bones of the wrist and ankle may show band-like shadows of varying density arranged parallel to the outline of the bones. There may also be enclosures of sharply demarcated foci of compact bone, the outline of which is similar to that of the bones in which they are included. These are seen in the metacarpal and metatarsal bones, the phalanges and the ribs.

C. Club-like thickening of the posterior clinoid processes and narrowing of the sella turcica are invariable findings. Frequently there is symmetrical widening of the ends of the long bones.

D. Aside from the clubbing other changes in the contour of the bones are uncommon. Shadows suggesting periosteal disturbances have been reported in a few instances.

E. Fractures are frequently present. Often the roentgenogram reveals the presence of old fractures of which the patient was not aware. There is usually evidence of normal healing with the production of abundant callus. In a very few cases delayed union has been described. Deformity of varying degree may be present as the result of the fractures.

F. With few exceptions there is no interference with the time of the appearance of the centers of ossification or the fusion of the epiphyses with the shafts. These centers share in the sclerosing process.

G. Roentgenographic evidence of concomitant suppurative disease of the bones is fairly common. The parts usually involved are the maxilla, mandible, femurs and scapulae.

H. The presence of rickets has been noted by three observers.

II. Increased fragility of the bones is in many cases recognized during infancy and childhood, and in practically all persons whose condition has been diagnosed in adult life, the presence of one or more fractures has been noted.

The fully developed syndrome consisting of pathologic fractures, roentgenographically opaque bones, retarded development, optic atrophy, anemia and enlargement of the lymphoid apparatus is not easily confused with any other disease. Osteosclerotic anemia has been reported. The changes in the bones in leukemia are essentially different from this syndrome. Numerous sclerosing diseases of bone, such as the condensing osteitis of Sicard, the eburniz-

ing osteitis of Putti, ivory vertebrae and the melorheostosis of Léri must be differentiated. Likewise lead poisoning, phosphorus poisoning and the use of irradiated ergosterol produce dense bands across the metaphyses of growing bone. Physiologic osteosclerosis of the newborn must also be borne in mind. This involves the whole skeleton and may represent a physiologic storage of calcium. The increased density disappears within the course of a few weeks. In osteogenesis imperfecta with pathological fractures, there is decreased rather than exaggerated density of the bones.

No form of beneficial therapy has been suggested. The treatment of the fractures is an orthopedic problem. There is very little to support the view that the condition is a parathyroid disturbance with treatment such as removal of parathyroid tissue. Bernhardt has noticed improvement with the use of ammonium chloride, notably some subjective betterment and an improvement in the blood picture.

The prognosis seems related directly to the severity of the manifestations and this in turn to the age at which the disease becomes clinically obvious. Those in whom the condition develops in utero and who present the complete clinical picture at the time of birth or within the first few months of life apparently survive for a relatively short length of time. The patients who do not have hydrocephalus have a better prognosis than those not so affected. Those whose sole symptom is pathologic fractures and in whom the disease has been discovered incidental to roentgen examination seem to do moderately well. There is insufficient information to determine whether the process is always progressive. Death usually results from intercurrent infections or from anemia. In some cases the former emanated from the foci of suppuration common to the disease.—*R. S. Bromer.*

McMASTER, PAUL E. Cartilaginous inclusions in rachitic bones and their possible relationship to cartilaginous tumors. *J. Bone & Joint Surg.*, April, 1935, *17*, 373–391.

McMaster presents a case of healed rickets in a white female child of five years of age who died of tuberculous meningitis. The patient had a past history of rickets and physical findings of a pigeon breast, Harrison's groove, and a rachitic rosary. At autopsy several long bones and portions of ribs and vertebrae were removed for study. Roentgenograms of the long bones showed healed rickets and only slight evidence of cartilaginous inclusions in the lower femoral epiphyseal center and in the upper humeral epiphyseal center. These were plainly shown on section of the bones. This indicates that these inclusions may easily be overlooked in the roentgenogram.

In experimental work on rats, McMaster found cartilaginous inclusions in the metaphyseal, epiphyseal and cortical regions of bone in cases of healed rickets. Microscopic studies showed that calcification was taking place in many of these areas. A few, however, appeared to be "latent" with slight, if any, evidence of calcification, and contained cells somewhat similar to those seen in a normal zone of proliferation in an epiphyseal plate. This proliferating type of cell in these rachitic inclusions might possibly serve as the "nidus" for benign cartilaginous tumors of bone.

He reproduces the roentgenograms of another case, a female child, aged two years, with active rickets and a fracture of the femur as shown in the roentgenogram. Fifty-two days later the rachitic process had healed but a large expanded circumscribed area in the cortical region of the lower metaphysis of the femur was present, suggestive of a rachitic cartilaginous inclusion. Two years later this had disappeared. Had calcification and ossification not occurred in this inclusion, it might well have served, McMaster observes, as the nidus for either a cartilaginous exostosis or a chondroma.—*R. S. Bromer.*

HOFFMAN, SAMUEL J. Neurocytoma derived from a ganglioneuroma of the hypogastric plexus. *Am. J. Dis. Child.*, Jan., 1935, *49*, 135–146.

Hoffman reports a case of ganglioneuroma of the hypogastric plexus in which microscopic section showed the transformation into the malignant form, neurocytoma. In the same section the non-malignant type of neurocytoma in the form of a ganglioneuroma and the true neurocytoma are shown.

Roentgenograms of various bones showed periostitis of the upper third of the left humerus, several ribs, the clavicles, the right femur and the upper portion of the tibia. The bones of the skull showed a granular appearance, with a lack of osseous detail and marked separation of the coronal suture. There was sclerosis, with areas of destruction in the lower third of the right femur and upper part of the tibia.

Hoffman regards the uniform thickening of the periosteum as an unusual form of metastasis. His patient was a negro child, male, aged three years.—*R. S. Bromer.*

Gunn, Francis D., and Nadler, Walter H. Osteomalacia. *Arch. Int. Med.*, July, 1934, *54*, 145–157.

A detailed report of the autopsy findings of a case of osteomalacia is presented. The patient was a male who developed this disease at nineteen years of age and died at forty-one from cardiac failure. During the eleven years of observation there were no significant findings aside from the bone change.

The differential diagnosis between hyperthyroid disease and osteomalacia is discussed. The diagnosis of the former depends upon the cystic condition of the bones, the high blood calcium and excessive excretion of calcium in the urine, plus a low concentration of serum phosphorus and an increased elimination in the urine. The author believes that osteomalacia is due to vitamin D deficiency and suggests that the condition is a form of adult rickets.—*J. H. Harris.*

Dorff, George B. Sporadic cretinism in one of twins; report of cases with roentgen demonstration of osseous changes that occurred in utero. *Am. J. Dis. Child.*, Dec., 1934, *48*, 1316–1325.

Dorff states that a review of the literature reveals a case of sporadic cretinism in one of male twins (the other being normal) reported by Herrman, an atypical case in each of male twins reported by Manson and a third case of suspected cretinism in each of twins reported by Petschacher. He reports 2 additional cases in which sporadic cretinism occurred in two sets of differently sexed twins, one twin in each set being involved, the other being normal in all respects.

In one of his patients, definite retardation of osseous development was shown by the roentgenogram at the age of seventeen months. There was an absence of the inferior epiphysis of the femur, of the inferior epiphysis of the tibia, of the carpal centers, of the distal epiphysis of the radius, of the epiphysis for the head of the humerus, of the epiphysis of the head of the femur and delayed development of the primary ossification centers of the pelvis. Since normally many of these ossifications either develop during the first year or are present at birth, he makes the deduction that this osseous retardation occurred during the fetal period and was truly congenital. He claims that for the first time such roentgen evidence has been put on record.

He believes that (*a*) there is an independent, low grade fetal thyroid activity which is not directly influenced by the maternal thyroid hormone; (*b*) there is probably no transmission of the thyroid hormone through the placenta from either the mother or the fetus. He stresses the importance of studying the development of the bones of the new-born suspected of hypothyroidism by roentgenograms.—*R. S. Bromer.*

Lichty, Dorman E. Lipoids and lipoid diseases. II. Xanthomatosis (Schüller-Christian's type). *Arch. Int. Med.*, March, 1934, *53*, 379–390.

The author reviews briefly the literature covering the clinical syndrome known as Schüller-Christian's disease and reports a case occurring in a twenty-one month old infant. The only unusual feature of the case report was the occurrence of a spontaneous fracture of the femur.—*J. H. Harris.*

Giles, Roy G. Epiphysitis. *Texas State J. Med.*, Jan., 1934, *29*, 562–564.

Some of the more common affections of the epiphyses are discussed. Clinically, these patients present few symptoms and the condition is frequently discovered accidentally. Similar roentgenographic changes are noted in the various epiphyseal derangements, all presenting areas of rarefaction and condensation, with indistinct outlines and a hazy, mottled appearance. Early recognition leads to early relief and the prevention of deformity.—*W. R. Brooksher.*

Karlin, I. W. Incidence of spina bifida occulta in children with and without enuresis. *Am. J. Dis. Child.*, Jan., 1935, *49*, 125–134.

This paper is based on a study of 25 children with the complaint of enuresis. In all of these children roentgen examinations of the lumbar spine and sacrum were made. Fifty normal children were also examined and in 54 per cent of these roentgenological evidence of spina bifida in the lumbosacral region was found. Frequently this as demonstrated on the roentgenogram is the only diagnostic evidence which can be obtained.

Spina bifida occulta is a developmental defect which indicates some abnormality in the process of embryogenesis in the region affected. It can only be considered as an organic basis of enuresis in those cases which show extensive involvement of the vertebrae in the lumbosacral region or which, in addition to a mild defect of a vertebra, present one or more confirmatory signs as described under the symptom-complex of myelodysplasia.—*R. S. Bromer.*

WILLIS, THEODORE A. Backward displacement of the fifth lumbar vertebra; an optical illusion. *J. Bone & Joint Surg.*, April, 1935, *17*, 347–352.

Willis was deeply intrigued by recent descriptions of the fifth lumbar vertebra subluxating up the steeply inclined surface of the sacrum. He wished to find the cause of this apparent optical illusion. He found, on study of the illustrations supposedly revealing this condition, that the posterior border of the lower articular surface of the last lumbar vertebra lay posterior to the posterior border of the upper surface of the sacrum, but the anterior surfaces were in normal alignment. In every instance, the anteroposterior diameter of the sacrum was less than that of the upper sacral segment. While the anterior borders were in alignment, the posterior borders overlapped.

He measured 50 consecutive skeletons in the catacombs of the Hamann Museum. In only 17 were these surfaces found to be of equal length. In 33 the anteroposterior diameter of the sacral surface was from one to four-sixteenths of an inch less than that of the opposing lumbar surface. Analysis of these surfaces showed the differences in anteroposterior depth to be due to the conformation of the posterior borders of the sacral surfaces. These varied from convexity to concavity toward the neural canal, while the posterior lumbar borders were regularly convex. The illusion of posterior displacement of the lumbar segment, then, can be attributed to relative shortening of the anteroposterior diameter of the first sacral segment.

The question of whether or not the angle of direction of the roentgen rays in the exposure of a roentgenogram can produce the appearance of displacement, Willis answers as follows: if the skeleton chosen for a model is the type, 34 per cent, having equal opposing last lumbar and first sacral surfaces, then naturally there can be no discrepancy in the roentgenogram. But if, by chance, the model used is one of the 66 per cent of skeletons having unequal anteroposterior diameters of these surfaces, then the central ray must be directed in such manner that it will outline the posterior portions of the two segments.

The question has been raised whether or not this condition, in the 66 per cent of skeletons, could in the living be a cause of low back pain. Willis concludes that it is probably of no clinical importance because it is found no more frequently in painful backs than in museum skeletons. It is certainly not to be considered a displacement.—*R. S. Bromer.*

## ROENTGEN AND RADIUM THERAPY

FORSSELL, GÖSTA. Über die Organisation der Krebsbekampfung. (The organization of the fight against cancer.) *Acta radiol.*, 1935, *16*, 99–128.

The author discusses the general principles which he thinks should be followed in the organization of an anticancer campaign. Details will of course differ in different countries, depending on the national characteristics of the people and the development of medical science in the country. As a general rule, however, effort should be directed to the reorganization and development of institutions already existing for the care of the sick and for scientific medical research rather than to the establishment of isolated institutions for the struggle against cancer. Large centralized institutions are better than small isolated ones because it is easier to have a throughly trained staff and adequate equipment, and particularly because the supply of radium available in the country should be concentrated rather than scattered in such small amounts that it is of little use.

Roentgen and radium treatment should be under the same chief and there must be the closest cooperation between the radiotherapist and the surgeon. It should be generally understood that radiotherapeutics is not merely a mechanical aid to medicine and surgery but that the radiotherapist must also be a skilled clinician and to a certain extent a surgeon, at least to the extent of understanding the surgical problems involved and of being able to perform minor operations that may become necessary in the course of radiotherapy.

Radiotherapy must be rendered available to

all cancer patients, no matter whether they are able to pay for it or not, and institutions provided for the care of those who are beyond hope of treatment. These may be cared for in other institutions for the convalescent and incurable; there is no reason for isolating the cancer patient, and in fact it is not advisable.

The organization must be such as to provide for early diagnosis and *immediate* treatment. There should be no delay in trying other treatments and none on account of lack of beds or personnel or official red tape in gaining admission to the hospital. Provision must be made for keeping the patient under observation for a long time after the treatment and there must be a social service follow-up to look after the family.

So far as possible the radiotherapeutic institutes should be connected with the universities so that they may be used for teaching purposes and also because that will tend to keep up the highest degree of scientific knowledge and technical skill in the institutions.

An international effort should be made to establish uniform cancer statistics. For this purpose reporting of cases and of the results of treatment should be made compulsory. The universities should give courses in cancerology and the treatment of tumors.

The private cancer societies have done a great deal in the way of stimulating cancer research and instructing the public. This work should be continued and coordinated with that of the state in providing treatment.—*Audrey G. Morgan.*

Bargen, J. Arnold, Horton, Bayard T., and Osterberg, Arnold E. The chemotherapy of cancer: I. Lead. *Am. J. Cancer,* April, 1935, *23*, 762–770.

Various colloidal metals, including gold, copper, selenium and lead have been used to combat the growth of cancer. Many who have tried this method of cancer therapy have been encouraged by the results obtained by either it alone or when the colloidal substances were used in conjunction with radiation therapy or surgery; other investigators consider the method futile or even detrimental.

The authors favor the use of colloidal lead phosphate. They have also tried its combination with magnesium phosphate, and in some cases, lead selenide. They found that the latter substance had to be injected much more cautiously, using greater dilutions and substituting the gravity method instead of the syringe; otherwise thromboses were formed. Colloidal lead phosphate was given in concentrations of 3.5 mg. of lead per 1 c.c., using an ordinary Luer syringe. The injections were made very slowly into the vein, usually in 10 c.c. amounts. Repeated injections were given usually over an interval of two weeks until a systemic lead poisoning was produced. An average of about 400 mg. was necessary though some patients were unable to tolerate this amount, while others received as much as 500 and even up to 892 mg.

This treatment was applied only to cases thought to be hopeless from the standpoint of other single therapeutic agents. The following routine studies were made: (1) blood cytological studies as to hemoglobin, red blood count, stipling, and leukocytes, (2) blood urea and renal function tests, (3) preliminary and interval urine analyses, (4) roentgenological studies as indicated, (5) biopsy when possible and (6) photography.

Of 81 cases treated and studied during the past two years, 60 were known to have died, 14 were known to be living—though one of these had recently developed metastases. Radiation therapy had been used in some of these cases. One case of a melano-epithelioma in which the lesion was huge and the lymph nodes of the groin formed a large nodular mass was treated solely with lead. The mass of nodes became necrotic during the course of treatment, so that very little neoplastic tissue could be found when they were excised for study. This patient was well four years after treatment. Other types of lesions which were at least partially aided included carcinoma and sarcoma of the breast, epithelioma of Bartholin's gland, carcinomas of the rectum, sigmoid, cecum, stomach, cervix and hypernephroma of the kidney.

The authors believe that when size, extent, and situation of a malignant growth make its complete removal impossible, the intravenous injection of lead seems to do something to bodily metabolism that tends toward suppression of the remaining cancer cells.—*A. A. de Lorimier.*

Faccini, Bruno. La terapie fisica degli epiteliomi cutanei. (Physical treatment of skin epitheliomata.) *Arch. di radiol.*, 1934, *10*, 553–563.

Within the past eight years the author has

used four methods of treatment of skin epitheliomata: (1) with roentgen rays; (2) with diathermocoagulation followed immediately by roentgen rays; (3) with diathermocoagulation followed after some time—generally eight to ten days—by roentgen rays; (4) with diathermocoagulation alone. From his experience he concludes that the method of treatment should depend not so much on the histological form of the tumor as on whether or not there is infiltration.

If there is infiltration of the glands he uses method 2 or 3, preferably method 2—diathermocoagulation followed immediately by roentgen therapy. If there is no infiltration it is probable that definite cure can be brought about by diathermocoagulation alone. He is not yet certain of this as his cases treated in this way are only two years old so it is not absolutely certain that there will not be recurrence. But so far all the patients are well and free of recurrence.

With roentgen treatment alone he has had a high percentage of recurrences and in one case a fatal result evidently due to the treatment. There was rapid dissemination of an epithelioma of the upper lip and death following a carcinoma dose with a spark gap of 38 cm. and a filtration the first time of 1 mm. aluminum and the second time of 0.5 mm. zinc and 3 mm. aluminum.—*Audrey G. Morgan.*

GUARINI, CARLO. La roentgen-terapia del simpatico. (Roentgen therapy of the sympathetic.) *Arch. di radiol.*, Nov.–Dec., 1934, *10*, 649–762.

There are various methods of applying roentgen therapy to the treatment of the sympathetic nervous system. Among these are axial roentgen therapy without filtration for skin diseases, regional roentgen therapy over the bifurcations of the vasomotor nerves for the purpose of influencing vasomotor diseases, roentgen therapy for distant skin lesions and roentgen therapy of the organs, such as the suprarenals for its effects on the sympathetic system.

A review is given of the literature of these various methods of roentgen therapy applied in the most varied diseases, followed by a long bibliography of the subject. Relief of pain and other symptoms is reported by many authors in various conditions.

The author concludes that while many phases of this field of treatment are still in the experimental stage, roentgen irradiation is known to have important effects on the neurovegetative nervous system. Gouin and Bienvenue hold that the increase in the number and change in the proportion of the leukocytes seen after roentgen irradiation is a hemoclastic crisis brought about by the action of the rays on the sympathetic nervous system.—*Audrey G. Morgan.*

JUGENBURG, ANNA; PERETZ, L. H., and MOSTOWA, R. S. Pathogenese, Prophylaxe und Therapie des Röntgenkaters. II. Mitteilung. (The pathogenesis, prophylaxis and treatment of roentgen sickness.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, March, 1935, *51*, 280.

In a previous paper in this Journal (Vol. 49, No. 6) the authors reported some preliminary studies on the changes in the intestinal flora as a contributing factor in the production of roentgen sickness. This paper is the further development of this conception. In the present study 43 patients who had roentgen irradiation of the abdomen were given Coli-sour-milk. This caused an increase in the *B. coli* content of the intestine and a marked decrease or absence of roentgen sickness after treatment.—*E. T. Leddy.*

TIMPANO, MARIO. Modificazioni ematologiche nel corso di roentgenterapia secondo la tecnica delle alte dosi frazionate e protratte. (Blood changes in the course of roentgen therapy with the technique of large fractional and protracted doses.) *Radiol. med.*, June, 1935, *22*, 579–598.

The blood picture was studied in 25 cases of malignant tumor that had been given roentgen treatment by the method of large fractional protracted doses (Coutard's method). Tables and graphs showing the details of the findings are given.

The author concludes that the quantitative and qualitative changes found in the blood cells caused by this method are just the same as those caused by other methods of deep roentgen therapy and similar to those found by Gallavresi in subjects who were given intensive radium therapy. The changes are chiefly in the white cells and are for the most part transitory. Often the reparative stage begins before the end of the treatment and within two months after the end of treatment the values have reached their permanent level. Generally a moderate leukopenia persists.

The clinical tolerance of the patients was perfect in all these cases. Before the treatment was half finished there were evident signs of improvement in the general condition. This shows that any harm done by the changes in the blood count, the lymphopenia in particular, is more than compensated for by the improvements brought about in the tumor. As to the possibility of basing prognosis on the course of the blood changes, the author has found that reëstablishment of the normal blood picture is more prompt and more complete in the cases with a favorable prognosis.—*Audrey G. Morgan.*

Rand, Carl W., and Taylor, Raymond G. Irradiation in the treatment of tumors of the pituitary gland. *Arch. Surg.*, Jan., 1935, *30*, 103–150.

A review of the literature indicates considerable difference of opinion concerning the effectiveness of roentgen irradiation of pituitary tumors. Many writers believe that irradiation is beneficial particularly in the chromophilic adenomata and possibly also in the chromophobe variety.

Of the 23 cases reported here 2 were classed as adenocarcinoma by the pathologist. These did not respond to irradiation. Two patients, one with supposed cystic adenoma, another with proved cystic chromophobe adenoma failed to respond to irradiation.

Five patients, all with acromegalic symptoms and presumably with chromophile tumors, showed marked improvement following irradiation, while 12 patients with presumed chromophobe adenomata showed variable responses to roentgen therapy. In the latter group slight improvement occurred in some, in some a diminution of visual acuity was arrested, while in others the vision continued to fail probably because of the cystic nature of the lesions.

The factors which the authors used were: 186 kv., 0.75 mm. Cu and 1.0 mm. Al filtration at 50 cm. distance, utilizing multiple portals 5 by 5 cm. in diameter. Patients were usually treated on alternate days giving a daily dose of 100 to 200 r (measured in air) at each treatment. Individual doses were small because of the danger of increasing the intracranial pressure. This was true except for the one case which had previously had a decompression.

The authors found that in the one case which came to autopsy there were no histological changes in the pituitary gland which could be attributed to irradiation. They also noted that surgical procedures subsequent to irradiation were no more difficult or less effective than where irradiation had not been used.—*G. W. Chamberlin.*

von Engelmayer, E. Neue (fraziokraniale) Bestrahlungswege zur Röntgentherapie der Hypophyse. (A new (faciocranial) method for irradiating the pituitary.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, April, 1935, *51*, 395.

To minimize the effects of irradiation on the brain the author uses a 2×5 cm. lead glass cone to center on the pituitary through fields on the face and jaws. The eyes are protected by leaded goggles. The deficiency of depth dose by the use of small fields is compensated for by using more fields, and the biological effect is thereby made to depend primarily on direct radiation. The method lessens cerebral reactions. This technique may be used along with a transcerebral or used in place of it.—*E. T. Leddy.*

Thorell, Ivan. Treatment of malignant tumors of the middle ear at Radiumhemmet, Stockholm. *Acta radiol.*, 1935, *16*, 242–253.

The author reviews the literature on the treatment of malignant tumors of the middle ear and 13 cases treated at the Radiumhemmet. They include 9 cases of cancer and 1 case of malignant melanoma, probably primary in the middle ear, 2 cases of malignant mucous and salivary gland tumors probably originating in the external auditory meatus and 1 case of sarcoma of the dura involving the middle ear. Of the 9 cases of cancer 2 are still free of symptoms nine and seven years after the beginning of the treatment. In one of these cases cure was brought about by irradiation alone, in the other by a combination of electrocoagulation and irradiation. Two patients with mucous and salivary gland tumors were free from recurrence for intervals of about a year at a time. One of them is now free and the other finally died. The patient with sarcoma of the dura is well nine years after operation followed by irradiation.

Experience with these tumors at the Radiumhemmet seems to show that the best treatment at present is a combination therapy based on the principles of the technique worked out by Holmgren, Öhngren and Berven for malignant tumors in the maxillo-ethmoidal region. In readily operable cases after possible

preoperative irradiation the treatment indicated is electrocoagulation and application of radium in the operation cavity, with possibly subsequent teleradium; in borderline and inoperable cases teleradium is indicated, possibly later combined with electrocoagulation and the application of radium in the wound cavity. One case well nine years after irradiation alone shows that cure is possible by that method. The cases treated entirely by irradiation were given a combination of roentgen and teleradium treatment. In the roentgen treatment 160 to 170 kv. was used, 3–6 ma., a distance of 30–50 cm. and a filter of 0.5 mm. copper and 1 mm. aluminum. The teleradium treatment has varied according to the amount of radium available. In recent years since Sievert's apparatus containing 3 gm. of radium has been used the treatment has been given at a distance of 6 cm. and the dose has been increased to a total of 70,000 to 100,000 mg-hr. over a period of two or three weeks.—*Audrey G. Morgan.*

POULTON, E. P., and WATT, W. L. Treatment of exophthalmic goitre with deep x-ray therapy. *Lancet*, Sept. 8, 1934, *2*, 535–537.

A series of 61 cases of exophthalmic goiter treated with deep roentgen rays is reported. The minimum period since commencement of treatment was three years and the maximum period of subsequent observation nine years.

The early cases received a total depth dose of about 25 per cent S.E.D. each treatment. It was found that two, three or even more treatments were necessary. The depth dose was then increased to about 50 per cent and was finally increased to a depth dose of 80 per cent S.E.D. as a standard. In the milder cases one treatment only and in the severer type two treatments are usually sufficient. A treatment consists of four irradiations—right, left, front and back—spread over five to seven days, with the patient in bed. The larger dosage is recommended because the longer the delay the greater the strain on the heart and the slower the recovery.

Only 20 cases of this group are classed as regards results: 11 can do full work; 8 can do their work with difficulty or are obliged to do lighter work and of these one had rheumatoid arthritis, one had mitral stenosis and treatment was not completed in another case; one patient who had had auricular fibrillation for two and a half years is classed as an invalid for life.

Forty additional cases are included in an addenum treated between July 1931 and July 1933. Early results show: in 22 cases marked improvement, in 55 per cent; in 14 cases definite improvement, 35 per cent; in 4 cases no change, 10 per cent.—*L. H. Osmond.*

FACCINI, BRUNO. La roentgen-terapia delle linfoadeniti e delle orchiepididymiti specifiche tubercolari. (Roentgen treatment of specific tuberculous lymphadenitis and orchiepididymitis.) *Arch. di radiol.*, 1934, *10*, 574–581.

The author has been treating tuberculous lymphadenitis and orchiepididymitis with roentgen rays for the past eight years and finds that there are few fields in which roentgen therapy is so effective. All of the cases he has treated in the eight years and has followed up have been cured and remained so.

He divides these diseases into two forms—the fibrous and the caseous. The dose used in the two forms is about the same but heavier filtration is used in the caseous group—0.5 mm. copper and 3 mm. aluminum. When the interval of rest between two applications was lengthened he found that the action of the rays continues for a much longer time than is generally supposed. He sometimes used as a supplementary treatment in cervical lymphadenitis injections of iodoform ether and in some cases alcohol compresses but no other form of treatment.

He believes that surgical treatment should be abandoned entirely in these conditions in favor of roentgen therapy as cure can be brought about in all cases without deforming scars or mutilation.—*Audrey G. Morgan.*

FACCINI, BRUNO. Osservazioni sulla roentgenterapia delle laringiti specifiche tubercolari e della tubercolosi polmonare. (Roentgen treatment of specific tuberculous laryngitis and pulmonary tuberculosis.) *Arch. di radiol.*, 1934, *10*, 564–573.

The author discusses these two conditions together as he finds that with very rare exceptions they are combined. Roentgen examination has shown evidences of lung involvement in cases in which physical examination was negative.

He divides tuberculous laryngitis into exudative and productive forms and these in turn into forms which are chiefly infiltrative or chiefly ulcerative. The technique used varies with the individual case and depends not so

much on the anatomical form of the lesion as on its site, because on the site depends the presence or absence of dysphagia from pain and the presence or absence of the irritation which causes paroxysmal cough, which in most cases causes vomiting and brings about malnutrition, and the condition of nutrition is really the decisive factor in whether a given case of tuberculosis can be cured or not.

He says that roentgen therapy is never contraindicated except in cases in which the patients are in extremely bad general condition. He has never seen aggravation of the lung condition from roentgen therapy. Though he has not treated a very large number of cases he believes that roentgen therapy should be used in tuberculosis of the larynx and lungs much more extensively at present as it gives very good results and does no harm.

He did not see any great difference in the results with the different techniques used nor did he see any marked difference when various medical treatments, such as calcium and gold therapy, were used.—*Audrey G. Morgan.*

Martinotti, Giuseppe. Plasmocitoma di ghiandole linfatiche trattato con raggi roentgen. (Case of plasmocytoma of lymphatic glands treated with roentgen rays.) *Radiol. med.*, Sept., 1935, *22*, 844–846.

Plasmocytomas are tumors made up of cells that are not very highly differentiated and labile and therefore sensitive to roentgen rays. Nevertheless few cases of this form of tumor treated by roentgen irradiation are reported in the literature.

The author therefore thinks it worth while to report a case in a man of sixty-five who in January, 1933, came for surgical treatment for a suppurated sebaceous cyst in the right hypogastric region. The surgeon at that time noticed a hard nodule in the left inguinal region. As the patient felt well he refused to have it removed but as it continued to enlarge he consented to operation in June. The histological diagnosis was malignant plasmocytoma. For some months the patient was well and did not return for periodical examinations as he had been advised to do by the surgeon. The first of September he returned with a large packet of glands in the operated inguinal region and a deep mass in the iliac fossa on the same side. As the surgeon thought this was an inoperable recurrence with metastases in the iliac glands he advised roentgen treatment.

The technique was as follows: 190 kv., 4 ma., focus-skin distance 30 cm., duration of irradiation 10 minutes; filter 2 mm. aluminum and 0.75 mm. zinc; fields 4×4 cm. There were four of these fields in the region to be irradiated and three applications were made to each field on alternate days, so that about 1,800 r was given on each field. The irradiation lasted from Sept. 4 to 18, 1933. A month after the last treatment there was a marked reduction in the size of the tumors. By the end of November the skin of the region was pigmented and elastic, the deep iliac mass had practically disappeared and in the inguinal region only a few small hard glands could be palpated. The patient was in excellent general condition. A second cycle of irradiations was given in November, using the same technique and giving about 1,200 r per field. Now nineteen months after the end of the treatment the patient is still in excellent general condition with no sign of local recurrence or metastasis.—*Audrey G. Morgan.*

Fischel, Ellis, Standard methods of treatment of cancer of the lip by surgery and radiation. *Surg., Gynec. & Obst.*, Feb. 15, 1935, *60*, 505–512.

No patient should ever die of cancer of the lower lip, because of the conspicuous position and because of the certainty of success in early cases. Treatment of primary lesions may be successfully accomplished either by electrodesiccation or other surgical measures, or sufficient doses of either roentgen rays or radium. The author removes primary lesions surgically when the diameter does not exceed 1 cm., larger lesions being treated by irradiation according to the following rules: (1) the area to be irradiated should comprise a great deal more than the visible or palpable margins of growth; (2) the estimated dose should be given in one sitting or a limited length of time (many radiologists will question this statement of a surgeon); (3) if the estimated dose has failed to cause complete retrogression, irradiation should not be persisted in. The prophylactic radiation therapy, as generally employed, is given with less intensity than when radiation is employed as a possible curative agent when metastases are definitely present. This seems illogical to the author.

The lymph channels from the lower lip are constant and the lymph nodes into which they drain are above the hyoid bone and from the

lower third of the parotid gland on one side to similar position on the opposite side. Crossed metastasis is of frequent occurrence. Primary metastases to more distant nodes are exceedingly rare as are, also, metastases to the lungs, mediastinum, or more distant parts of the body. The author found that of 42 cases with palpable lymph nodes only 14 of these proved to be carcinomatous, and of 13 cases in which there were no palpable lymph nodes microscopic examination showed carcinoma to be present in the nodes in two.

The author recommends routine dissection of the nodes of the neck in all cases, with or without palpable nodes. This is performed one and a half to three months after treatment of the primary lesion. In advanced cases with metastasis he recommends interstitial irradiation of metastatic nodes.—*J. H. Vastine.*

AHLBOM, HUGO E. In der Haut und Subkutis lokalisierte sog. Mischtumoren vom Typ der Schleim- und Speicheldrüsengeschwülste und ihre Behandlung. (So-called mixed tumors of the type of mucous and salivary gland tumors localized in the skin and subcutaneous tissue and their treatment.) *Acta radiol.*, 1935, *16*, 178–183.

So-called mixed tumors of the parotid type occur in the skin and subcutaneous tissue and are usually benign. They are most frequently found on the skin of the face but a few are found on the trunk and extremities. Three such tumors, two on the face and one on the sole of the foot, have been treated at the Radiumhemmet and in all of them histological examination showed a certain degree of malignancy. Clinically these malignant so-called mixed tumors may be mistaken for the common types of skin cancer. As in mucous and salivary gland tumors the best treatment is generally a combination of surgery and irradiation. The tumors consist in part of myxomatous tissue and tissue resembling cartilage and as a rule they are only slightly radiosensitive. Some of them, however, with a simpler structure (fibroepitheliomas) may be radiosensitive and may therefore be treated successfully by radiotherapy alone.—*Audrey G. Morgan.*

PALMSTIERNA, KULE. The nourishment in cases of radiological reaction in the mucous membranes of the mouth and throat. *Acta radiol.*, 1935, *16*, 301–303.

In cases of malignant tumors of the mouth and throat treated by radiotherapy, it is generally difficult for the patients to eat after the reaction begins. The author describes a mixture which has been used successfully in such cases. It consists of:

1000 gm. milk
40 gm. butter
20 gm. wheat flour
30 gm. maltose
the yolk of one egg

This means 1,100 calories per liter with 32 gm. albumin, 70 gm. fat and 80 gm. carbohydrate. One and one-half liters of the mixture just about satisfies the patient's caloric requirement.

The butter is melted in a saucepan over a slow fire and stirred with a wooden spoon. The flour is then added gradually and the heating is continued, stirring until the mass has become fluid and brownish. The milk in which the maltose has been dissolved is then added. The mixture is well boiled and after cooling a beaten egg yolk is added.—*Audrey G. Morgan.*

*Pach Brothers, New York*

CHARLES A. WATERS

PRESIDENT OF THE AMERICAN ROENTGEN RAY SOCIETY

1936–1937